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IAFI

PROPOSED FURTHER UPDATES TO THE WORKING DOCUMENT TOWARDS A NEW APT REPORT ON WAS/RLAN TECHNOLOGY, USE CASES, SPECTRUM DEMAND AND REGULATORY DEVELOPMENT

1. Background

The AWG is developing a new APT report on Radio Local Area Networks (RLAN). During the last AWG-32 meeting, the working document towards a new APT Report on RLANs (AWG-32/TMP-27 Rev.1) was further updated based on several contributions and responses to Questionnaires from some administrations, and the discussion moved on updating the actual content of the document

2. Discussion

Many countries in the Asia Pacific region are now recognizing the potential of RLANS to enhance wireless connectivity. The 6 GHz band offers a substantial increase in available bandwidth for Wi-Fi services, enabling faster speeds, lower latency, and improved capacity for a variety of applications. Regulators in the United States, the European Union, the United Kingdom, and several other regions have moved towards opening up the entire 6 GHz band for unlicensed use, supporting the deployment of Wi-Fi 6E and upcoming Wi-Fi 7 technologies. However, considering the increased needs of 5G for mid bands, some countries in Asia pacific Region are also considering the upper 6GHz band for 5G. However, the Lower 6GHz band has found a universal acceptance for unlicensed Wi-Fi adaptations .These regulatory changes are driven by the growing demand for wireless broadband, fuelled by increasing data consumption, the proliferation of connected devices, and the need for robust and reliable Wi-Fi networks in homes, businesses, and public spaces. However, the allocation of the 6 GHz band is being approached with caution to avoid interference with incumbent users such as fixed satellite services, and point-to-point microwave links. As a result, regulatory frameworks often include provisions for dynamic frequency selection, automated frequency coordination, and power limits to ensure coexistence and protect existing services while maximizing the benefits of the expanded Wi-Fi spectrum. The information in this report has been updated to address these issues.

3. Proposal

IAFI proposes further modifications to the working document, as contained in Attachment with the aim of completing this Report. The proposed revisions are highlighted in turquoise

Contact: Bharat Bhatia
IAFI, INDIA

Email:
Bharat.Bhatia@iafi.in

Working document towards a new APT Report on WAS/RLAN Technology, Use Cases, Spectrum Demand and Regulatory Development

[Editor's note: This working document is developed based on inputs:
- AWG-30/INP-27
- AWG-31/INP-56Rev.1, 95
- AWG-32/INP-13Rev.1, 18, 22, 27, 28, 33, 43, 45, 47, 60, 85, 92, 99]

[Editor's note: The text of this report needs to be carefully reviewed in future meeting. Input contributions are invited.]

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1. Scope

This Report provides an overview of technology developments and implementation aspects of [unlicensed] Wireless Access Systems, Radio Local Area Networks (WAS/RLAN). It reviews the technology evolution in frequency bands such as 5 GHz, 6 GHz, [7 GHz], 60 GHz.

The report covers an overview of:

- Global trends in adoption of wireless access systems that support local area networks utilising Radio Local Area Networks (WAS/RLAN) technologies ,
- On-going industry developments, [standards] and technical improvements in WAS/RLAN technologies
- Use cases and experiences of implementation of Radio Local Area Networks (WAS/RLAN)
- Information on WAS/RLAN rules adopted by APT and non-APT administrations

[Some of] the RLAN technologies covered in this report are based on the scope of Recommendation ITU-R M.1450 "Characteristics of broadband radio local area networks," which contains characteristics of RLAN standards.

This new APT Report provides an overview of the latest WAS/RLAN technology, use cases, spectrum demand and regulatory developments.

2. Introduction

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Internet connectivity is an essential socioeconomic function and WAS/RLAN [, which is the most successful RLAN technology,] is the primary means of delivering it to billions of users around the world. Statistics from Cisco show Wi-Fi networks carried 52.6% of the world's total Internet traffic in 2021[1]. Wi-Fi plays a vital role in global economic development. According to a report from Wi-Fi Alliance[2], the connectivity provided by Wi-Fi through lower-cost devices delivers trillions of dollars in value to the global economy.

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Multiple technologies operate in the Radio Local Area Networks (RLAN) domain. These technologies, following both IEEE and 3GPP standards, play a significant role in broadening wireless connectivity options for users by expanding access and optimizing resource utilization through the use of unlicensed or locally licensed spectrum. This offers an opportunity to support innovation, competition, and inclusivity within the wireless landscape, which can lead to enhanced accessibility and efficiency in wireless communications.

In today's hyper-connected world, unlicensed WAS, that includes Wi-Fi and 5G-NRU has become an indispensable part of our daily lives, enabling seamless communication, collaboration, and access to information. Among its various frequency bands, the 6GHz spectrum stands out as a critical resource for WAS networks, offering significant advantages in terms of speed, capacity, and reliability. WAS networks provide ubiquitous connectivity, allowing users to access the internet and communicate wirelessly across a wide range of devices, including smartphones, laptops, tablets, IoT devices, and more. WAS enables users to connect to the internet and local networks without the constraints of physical cables, enhancing mobility and flexibility in various environments, such as homes, offices, public spaces, and outdoor areas. WAS networks can easily be scaled to accommodate growing numbers of users and devices, making them a cost-effective solution for both individuals and organizations. WAS has evolved into critical infrastructure for modern society, supporting essential services such as education, healthcare, business operations, and emergency communications. WAS plays a pivotal role in enabling connectivity, fostering innovation, and driving economic growth worldwide. Global harmonization of spectrum allocations and economies of scale are essential factors that contribute to the successful deployment and widespread adoption of unlicensed WAS technology, ensuring its continued evolution and relevance in the digital age.

The 6GHz spectrum offers significantly wider channels and faster data rates compared to lower frequency bands, enabling faster and more reliable wireless connections for bandwidth-intensive applications such as high-definition video streaming, online gaming, and virtual reality. With more available spectrum, the 6GHz band helps alleviate congestion in existing Wi-Fi frequencies, resulting in improved network performance and better quality of

[1] Cisco's Internet Traffic Report & Forecast.
[2] Wi-Fi Alliance, Global Economic Value of Wi-Fi® 2021 – 2025

service for users, as well as enabling the use of less expensive 5G-NRU indoor solutions for specific applications. By operating in a relatively uncongested frequency range, 6GHz WAS networks experience less interference from other wireless devices, ensuring more stable and consistent connectivity.

Global and Regional harmonization of unlicensed WAS spectrum allocations ensures interoperability between devices and networks worldwide, facilitating seamless roaming and compatibility for users across different regions. Harmonized spectrum policies promote efficient spectrum management practices, enabling spectrum sharing and maximizing the use of available frequency bands without causing harmful interference to other services. A globally harmonized approach to unlicensed WAS spectrum allocation encourages innovation and investment in new technologies and services, driving economic growth and competitiveness on a global scale.

Economies of scale enable manufacturers to achieve lower production costs per unit by scaling up production volumes, resulting in more affordable unlicensed WAS devices and equipment for consumers and businesses. Lower costs and increased availability of unlicensed WAS technology due to economies of scale encourage widespread adoption and deployment of unlicensed WAS networks, benefiting both end-users and service providers. Economies of scale incentivize continued innovation and advancement in unlicensed WAS technology, driving the development of more efficient, reliable, and secure wireless networking solutions utilizing either Wi-Fi and /or 5G-NRU.

[Editor’s note: Same text also in Section 6]
[
The demand for wireless broadband is increasing at a phenomenal pace, as citizens and businesses groups are increasingly relying on Internet connectivity. To meet this demand, the various administrations are continuously evaluating the use of the spectrum available for the use of WAS/RLAN in more efficient usage using a variety of methods, including unlicensed operations.
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The 6 GHz band is comprised of allocations for Fixed Services, Fixed Satellite Services (FSS) and Mobile Services across sub-bands. Fixed microwave service licensees, specifically those operating point-to-point microwave links for supporting variety of critical services commercial, private entities, and public safety agencies, are the largest user group in the 6 GHz band.
The Fixed Satellite Service (FSS) (Earth-to-space) is allocated in all sub-bands of 6 GHz, except for the 7.075-7.125 GHz portion. FSS operations are heaviest in the 6 GHz band, which is paired with the 3.7-4.2 GHz, space-to-Earth frequency band. Predominant FSS uses of these frequencies include content distribution to television and radio broadcasters, including transportable antennas to cover live news and sports events, cable television and small master antenna systems, and backhaul of telephone and data traffic.
]
[Editor’s note: Below paragraph also proposed to be included in Section 7.1 by one input]
[
Considering the existing and anticipated congestion, many administrations decided to provide additional spectrum to complement spectrum where Wi-Fi is presently deployed, to ease any congestion so that businesses and consumers can take advantage of new data intensive applications. By making this spectrum available for unlicensed use, cable companies and

wireless carriers started expanding their Wi-Fi hotspot networks to provide customers' access to even higher speed data connections, than they experience today and expand their networks in areas where they need additional capacity.
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[
Some administrations allocated entire 6 GHz from 5925 – 7125 MHz, as unlicensed 3rd frequency band for WAS/RLAN. So, a contiguous 1200-megahertz block of spectrum is now available in some countries for the development of new and innovative high-speed, short range WAS/RLAN devices.
]
WAS/RLAN has proved the most popular way of internet connectivity to multiple devices without cables and wiring, in home and business networks, making it a most popular choice. WAS/RLAN-enabled devices such as smartphones, tablets, laptops, and smart home devices can be connected to the internet easily without the need for any physical connection, to a WAS/RLAN modem or router. WAS/RLAN also allows multiple devices to connect to the internet simultaneously, making it a convenient and cost-effective way to provide internet access in homes, offices, and public spaces. Even large proportion of the mobile data traffic is now delivered to the end user through WAS/RLAN devices. Therefore, the demand devices capable to access internet wireless broadband though WAS/RLAN, is growing at a phenomenal pace. Presently, there are almost 25 billion WAS/RLAN connected devices in the world and almost 3 mobile device every person.
So, the wireless highways through which Wi-Fi traffic moves are congested and will continue to get more crowded. Main reasons are:

(a) Every house is installed with one WAS/RLAN modem and even few having more than one.
(b) Many communities are served with public WAS/RLAN.
(c) Increased in demand of speed of internet requires wider channel.
(d) Cellular operators are dumping traffic into the WAS/RLAN spectrum, onto the unlicensed spectrum used by WAS/RLAN.

Presently, several unlicensed frequency bands have been allocated for WAS/RLAN. It's should be noted that the allowed frequency range may vary depending on each administration's decision.

(a) 2.4 GHz band – from 2400.00 to 2483.50 MHz = 83.50 MHz, having 3 channels of 20 MHz or 1 channel of 40 MHz.

(b) 5.0 GHz band –Parts of 5150-5925 MHz (*5 150-5 250 MHz, 5 250-5 350 MHz and 5 470-5 850 MHz)* having 25 channels of 20 MHz or12 channels of 40 MHz or 6 channels of 80 MHz or 2 channels of 160 MHz.

(c) 60GHz band- from 57-71GHz, with channel bandwidth up to 2160MHz

[
So, only 883.50 MHz spectrum in 2.4 GHz and 5.0 GHz band has been allocated for unlicensed band for Wi-Fi. Studies have shown that there is a need of at least 2 GHz spectrum to meet the increased need to respond to increased home working, particularly in high human density countries such as India. Currently unlicensed Wi-Fi spectrum is inadequate to meet out the growing demand.

So, to meet out the growing demand of Wi-Fi spectrum, it is proposed to harmonize the 1200 megahertz of spectrum available in the 6 gigahertz (GHz) band from 5.925 GHz to 7.125 GHz, to be assigned as unlicensed band for Wi-Fi devices. Unlicensed devices will share this spectrum with incumbent licensed services under rules that are carefully crafted to protect those licensed services and to enable both unlicensed and licensed operations to thrive throughout the band. More than 32 countries in the world including developed economies like USA, Canada, Australia, Japan and EU have already allotted the 5925-7125 MHz band for the use of unlicensed Wi-Fi.

The 6 GHz Wi-Fi spectrum is 1200 MHz wide (more than double the total size of the 2.4 GHz and 5 GHz spectrums) and supports up to 59 channels of 20 MHz or 29 channels of 40 MHz or 14 channels of 80 MHz or 7 channels of 160 MHz channels and 3 channels of 320 MHz. These channels are only accessible to new Wi-Fi 6E devices and enable gigabit Wi-Fi speeds and allow operations free from legacy Wi-Fi interference.

So, 6 GHz frequency band is uniquely suited to meet growing demand for Wi-Fi connectivity, as there is no alternative spectrum now or in the future.
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The extension of 3GPP technologies into unlicensed spectrum bands stems from years of collaborative efforts across diverse industries and technical domains. These efforts have led to the development of New Radio Unlicensed (NR-U) as a suitable option for RLAN. Through extensive engagement in standards and regulatory discussions, experts from cellular technologies based on 3GPP standards and Wi-Fi technology based on IEEE standards have contributed to this achievement. NR-U's operation within the unlicensed spectrum offers expanded access, particularly in areas where traditional Wi-Fi coverage may be lacking. Moreover, the potential for enhanced coverage and throughput in unlicensed spectrum is further bolstered by carrier aggregation, which integrates carriers from licensed and unlicensed spectrums to optimize channel utilization and reliability.
[Editor’s note: hyperlinks to the references may be provided]

3. References

[1] Aruba Whitepaper - Technical Guide to Wi-Fi 6E and the 6 GHz band.

[2] IEEE Standard for Information technology--Telecommunications and information exchange between systems Local and metropolitan area networks--Specific requirements Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications," IEEE Std 802.11-2020 https://ieeexplore.ieee.org/document/9363693

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[4] FCC-20-51A1, In the Matter of Unlicensed Use of the 6 GHz Band Expanding Flexible Use in Mid-Band Spectrum Between 3.7 and 24 GHz, REPORT AND ORDER AND

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[6] ECC Report 302, Sharing and compatibility studies related to Wireless Access Systems including Radio Local Area Networks (WAS/RLAN) in the frequency band 5925 - 6425 MHz.

[7] Recommendation ITU-R RA.769-2: "Protection criteria used for radio astronomical measurements"

[8] M. Mehrnoush, C. Hu and C. Aldana, "AR/VR Spectrum Requirement for Wi-Fi 6E and Beyond," in IEEE Access, vol. 10, pp. 133016-133026, 2022, doi: 10.1109/ACCESS.2022.3231229.

[9] Cisco Whitepaper - IEEE 802.11ax: The Sixth Generation of Wi-Fi White Paper.

[10] Intel Corporation – Next generation Wi-Fi - Wi-Fi 7 and beyond

[11] Giordano, L. G., Geraci, G., Carrascosa, M., & Bellalta, B. (2023). What Will Wi-Fi 8 Be? A Primer on IEEE 802.11 bn Ultra High Reliability. arXiv preprint arXiv:2303.10442.

[12] Recommendation ITU-R M.1450: “Characteristics of broadband radio local area networks”

[13] 3GPP, TS 38.300, “NR and NG-RAN Overall Description; Stage 2 (Release 18),” 2023.

[14] 3GPP, TR 38.808, “Study on supporting NR from 52.6 GHz to 71 GHz (Release 17),” 2021.

4. Abbreviations and acronyms

Acronyms	Definition
AFC	Automated Frequency Coordination
AP	Access Point
BEL	Building Entry Loss
BSS	Basic Service Set
DFS	Dynamic Frequency Selection
DUT	Device Under Test
EIRP	Equivalent Isotopically Radiated Power
FS	Fixed Service
FSS	Fixed Satellite Service
LPI	Lower Power Indoor
PL	Path Loss
RAS	Radio Astronomy Services

Acronyms	Definition
RX	Receiver
SP	Standard Power
TX	Transmitter
ULS	Universal Licensing System
VLP	Very Low Power
Wi-Fi	Wireless Fidelity
FSS	Fixed Satellite Service
IMT	International Mobile Telecommunications
WRC	World Radiocommunication Conference
LTE	Long Term Evolution
RLAN	Radio Local Area Network, also known as WLAN or Wi-Fi
WAS	Wireless Access System
NR	5G New Radio
IEEE	Institute of Electrical and Electronics Engineers
3GPP	The 3rd Generation Partnership Project
NR-U	5G NR in unlicensed spectrum
SON	NR Self-Organizing Networks
TSN	Time-sensitive Networking
IIoT	Industrial Internet of Things
eURLLC	enhanced Ultra-reliable Low-latency Communications

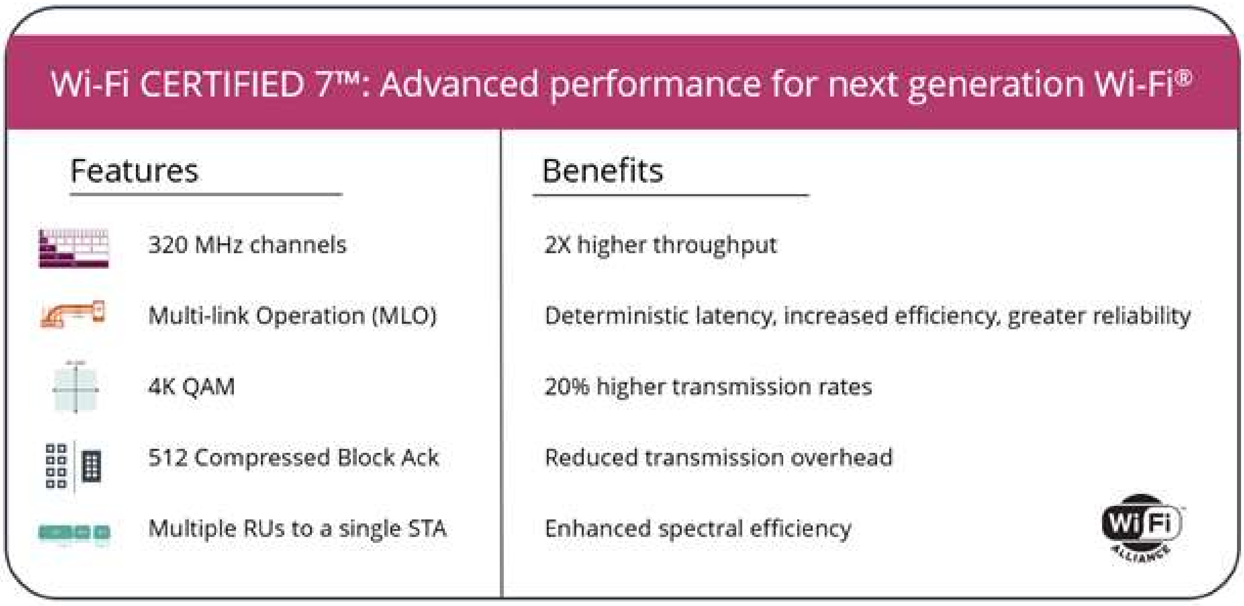
5. Technologies used for WAS/RLAN

[Editor's note: Sub-sections here (5.x) will include a brief description of technologies]

5.1 Wi-Fi Technology for RLAN networks

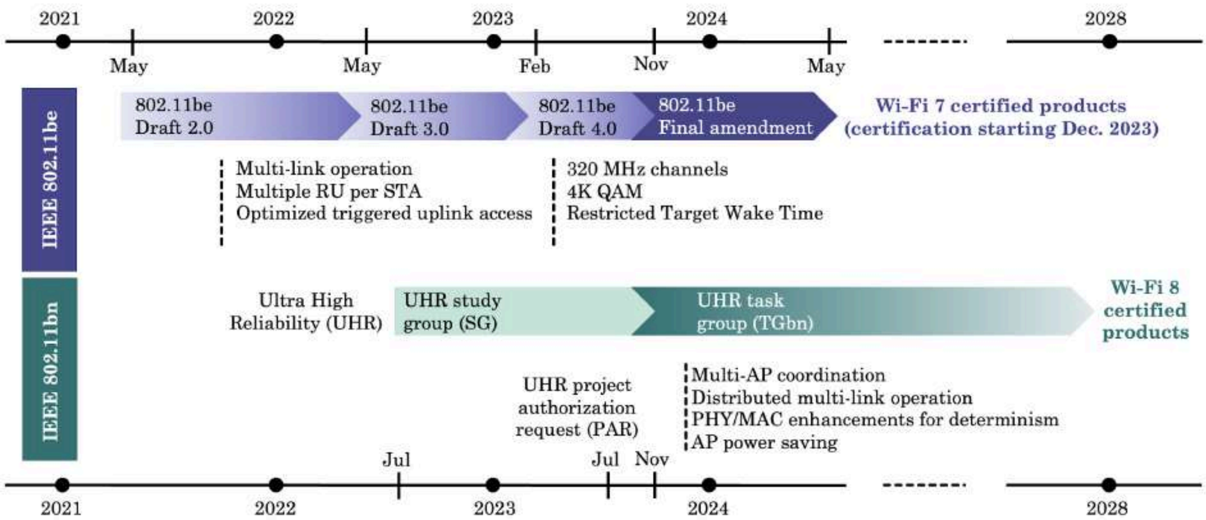
Since Wi-Fi was first released to consumers in 1997, Wi-Fi standards have been continually evolving – typically resulting in higher throughput, more capacity and increased coverage. In the last 5 years, the Wi-Fi standards body, IEEE 802.11, developed two generations of Wi-Fi standards, commercially known as Wi-Fi 6 and 7. After seeing the spectrum congestion in existing 2.4 and 5 GHz license-exempt bands, Wi-Fi 6E extends its frequency range to 6 GHz (5925 – 7125 MHz). With the 6 GHz band, enterprises can support new use cases that require multi-gigabit speeds, larger numbers of channels, and millisecond levels of latency.

Wi-Fi 7 builds on Wi-Fi 6E's access to the 6 GHz band and increases data rates to over 40 Gb/s by using 320 MHz channels and 4K QAM modulation. In addition, Wi-Fi 7 will also further reduce the network latency and improve link robustness in the presence of interference via features such as Multi-Link Operation (MLO). Commercially, Wi-Fi alliance already started Wi-Fi 7 product certification since the beginning of 2024.



New features in IEEE 802.11be (Wi-Fi 7)

Although Wi-Fi 7 is a relatively recent standard, standardization work for the next generation, 802.11bn (Wi-Fi 8), is already on the agenda of the IEEE 802.11 working group.
IEEE 802.11bn focus on Ultra High Reliability (UHR) communication in RLAN networks. UHR is a newly established Study Group within the IEEE 802.11 working group that will investigate PHY and MAC technologies to improve reliability of WLAN connectivity, reduce latencies, increase manageability, increase throughput including at different SNR levels and reduce device level power consumption. It is expected Wi-Fi 8 certified products will be available in 2028.



Current standardization, certification, and commercialization timelines for IEEE 802.11be (top) and IEEE 802.11bn (bottom).

Wi-Fi technology uses license-exempt spectrum and must allow adjacent uncoordinated networks to coexist whilst providing high service quality to users.

[

But recently, the spectrum congestion for Wi-Fi networks has been acute due to the exponential growth of device numbers and data traffic. Since the WRC-2003, no new mid-band license-exempt spectrum has been made available for Wi-Fi. Furthermore, the 2.4 and 5 GHz Wi-Fi spectrum doesn't offer a sufficient number of wide channels for newer applications and services, and the supported narrow channels at 20 and 40 MHz are not capable of the throughputs offered by many current broadband access technologies (e.g. fiber, DOCSIS, and Fixed-Wireless services).
]

5.1.1 Industry and regulatory development for 6 GHz Wi-Fi

Since the FCC opened the 6 GHz band for Wi-Fi, there has been a strong momentum of Wi-Fi 6E device ecosystem development. According to Intel's data tracker[3], the total number of Wi-Fi 6E-capable devices reached 1262 by the end of Q4 2022. The number includes PCs (by far the majority), phones, APs, and TVs. The count finished strongly for 2022 with the number of Wi-Fi 6E devices growing by more than 2.5 times from end of Q1 to end of Q4 last year. It is forecasted that by 2025, Wi-Fi 6 and Wi-Fi 6E are expected to surpass 80 percent market share and dominate Wi-Fi connectivity in the smartphone segment.

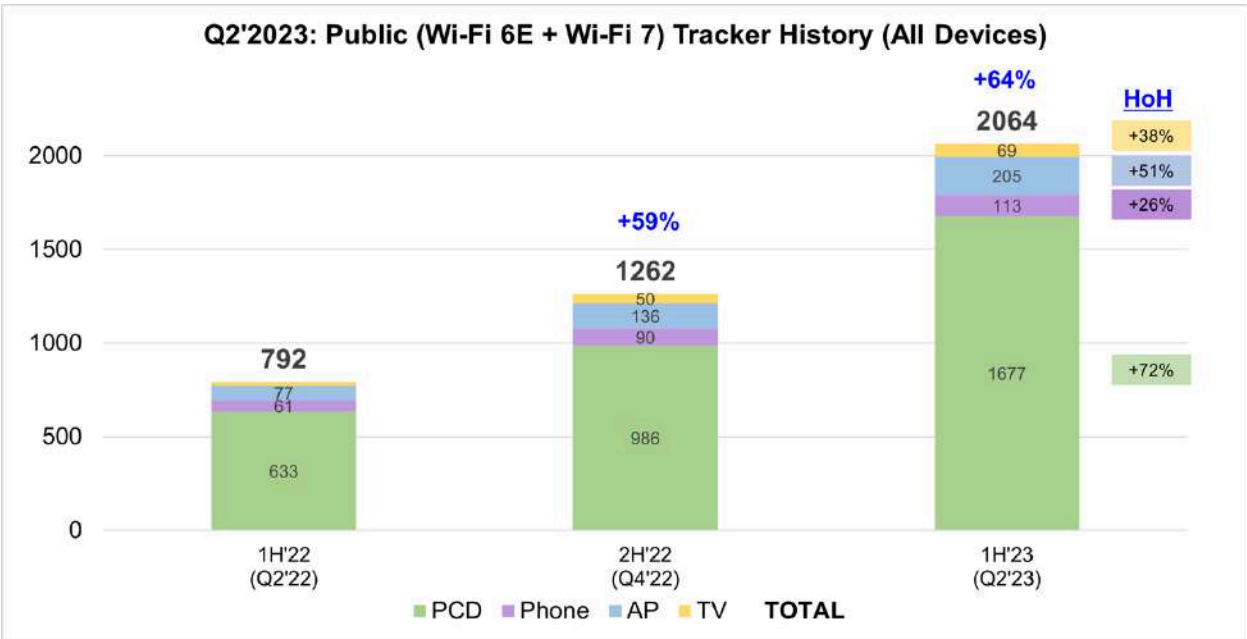


Figure 5 Public Wi-Fi 6E/7 device model track history

5.1.2 Channel and Spectrum usage of Wi-Fi technology

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RLAN (Radio Local Area Network) is a type of wireless communication technology that allows devices to communicate with each other over a local area network (LAN) using radio frequency (RF) signals. RLANs are also commonly referred to as WLANs (Wireless Local Area Networks) or Wi-Fi networks.

The basic operation of RLAN involves a wireless access point (AP) or router that acts as a central hub for wireless devices to connect to the network. The AP is connected to the wired LAN and serves as a bridge between the wired and wireless networks.

3 https://wifinowglobal.com/news-and-blog/intel-says-wi-fi-6e-device-count-passes-1200-more-apple-iphone-15-wi-fi-6e-rumours/

When a wireless device, such as a laptop or smart phone, wants to connect to the RLAN, it sends a request to the AP to join the network. The AP authenticates the device and assigns it an IP address. Once the device is connected, it can communicate with other devices on the network and access the Internet.

The RLAN network are secured as using various encryption and authentication protocols, such as WPA2 (Wi-Fi Protected Access II) and 802.1x. These protocols provide protection against unauthorized access and ensure the confidentiality and integrity of the data transmitted over the network.

Radio local area networks (RLANs) systems are quickly emerging as a preferred access technology. RLAN uses different frequency bands for communication, such as the 2.4 GHz and 5 GHz bands. RLAN consortium proposes to introduce unlicensed Wireless point to point and point to multipoint devices into the 5.925 to 7.125 GHz band.

In wireless communication systems, channel assignment refers to a process of allocating radio frequency channels to different users or devices in order to optimize the use of the available spectrum and minimize interference.

There are several approaches to channel assignment in RLANs, including: -

(a) Fixed channel assignment: In this approach, each AP is assigned a fixed channel that is pre-determined based on factors such as signal strength, interference level, and available bandwidth.
(b) Dynamic channel assignment: In this approach, the channel assignment is dynamically adjusted based on the current network conditions, such as the number of active users and the level of interference.
(c) Channel hopping: In this approach, the APs or wireless devices periodically switch channels in order to avoid interference and improve overall network performance.

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5.1.2.1 New spectrum in the 6 GHz band

[Editor's Note: add additional reasoning for why 6GHz and rationale for additional spectrum; also include WIFI 7 and 320 MHz channels]

The 6 GHz band encompasses 1200 MHz of spectrum from 5925 – 7125 MHz, compared to 83.8 MHz in the 2.4 GHz band and 570 MHz in sections of 5 GHz. Some countries and regions have enacted a 20 MHz guard band from 5925 – 5945 MHz to protect DSRC/CV2X services.

This allows for 59x20 MHz wide channels; 29x40 MHz; 14x80 MHz, or 7x160 MHz. The number of wide channels is especially significant, as gaps in allocated spectrum in the 5 GHz band limit 80 MHz channels to 7 and 160 MHz channels to 3, and wide channels are necessary for the highest data rates possible with the latest generations of Wi-Fi technology.

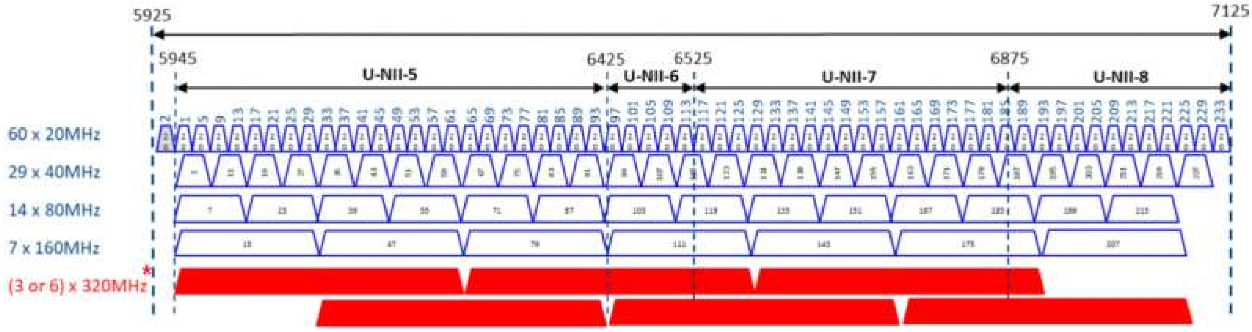


Figure 3 6GHz Wi-Fi Channels plan

The 6 GHz band is uniquely suited to address the demand for additional Wi-Fi spectrum for the following principal reasons:

a) The 6GHz band will be able to support wide channel bandwidth for dense Wi-Fi networks.

A shared license-exempt band requires multiple radio channels in order to distribute load and reduce co-channel interference (CCI). It is well known that 2.4 GHz with only 3 non-overlapping channels is heavily congested around the world. This is depicted on the left of Figure 4. It is commonly understood by the industry and academia that self-coordinated Wi-Fi requires no fewer than about seven to nine non-overlapping radio channels in a typical corporate or campus deployment to absorb current demand levels, as shown in the middle diagram of Figure 4. For large public venue environments with extreme loading levels such as stadia, arenas, university lecture halls, and airports research and years of experience have proven that 20 or more discrete channels are required for Wi-Fi to operate successfully and carry the tremendous levels of traffic at such venues. Every major enterprise Wi-Fi equipment manufacturer has historically published detailed design guidelines for such large venues calling for 20 MHz channels to be used, because only this narrowest channel width yielded a sufficient number of non-overlapping channels in the 5 GHz band.[4]

The principle behind this phenomenon is that having fewer channels increases the probability of collisions between co-channel radio cells, even at low loading levels. An obvious reason for this is depicted in Figure 4, where nodes in a Wi-Fi network with small inter-cell distances can “hear” many more co-channel radios. But a more subtle effect is the resulting rise in the noise floor from “hidden” Wi-Fi cells. This increasing the collision probability and reduces the available signal-to-noise level, which in turn reduces the data rate, thereby making each transmission take longer (increased latency) . By contrast, having more channels both reduces the absolute number of “hearable” co-channel cells, and helps keep the noise floor nearer the thermal limit, which maximizes data rates and therefore transmits data more quickly – requiring less airtime. This attribute of Wi-Fi enables well-designed networks with a sufficient number of channels to absorb extremely high demand surges.

The 5 GHz band is only able to provide 5x80MHz or 3x160MHz channels, which are not sufficient to deploy a useful Wi-Fi network. Network operators are forced to use narrower channels such as 40 MHz or even 20 MHz, which limit the peak data throughput under 600 Mbps for a typical device in even optimal RF conditions. Given that multi-gigabit broadband

[4] “Very High Density 802.11ac Networks”, Aruba Networks, 2015, https://higherlogicdownload.s3.amazonaws.com/HPE/MigratedAssets/Aruba_Very_High_Density_802.11ac_Networks_VRD.zip

connections are being more and more widely adopted, narrow band Wi-Fi networks become the bottleneck of overall network performance and user experience.

The 1200 MHz of spectrum in the 6 GHz band yields an equivalent number of 80 MHz channels as there are 40 MHz channels in the 5 GHz band. With 1200 MHz of spectrum in the 6 GHz band, 80 MHz channels will become the default in the large majority of enterprise deployments. It even allows 7x160 MHz or 3x320MHz channels that can enable novel use cases like Augmented/Virtual Reality which require low latency and extremely high throughput.

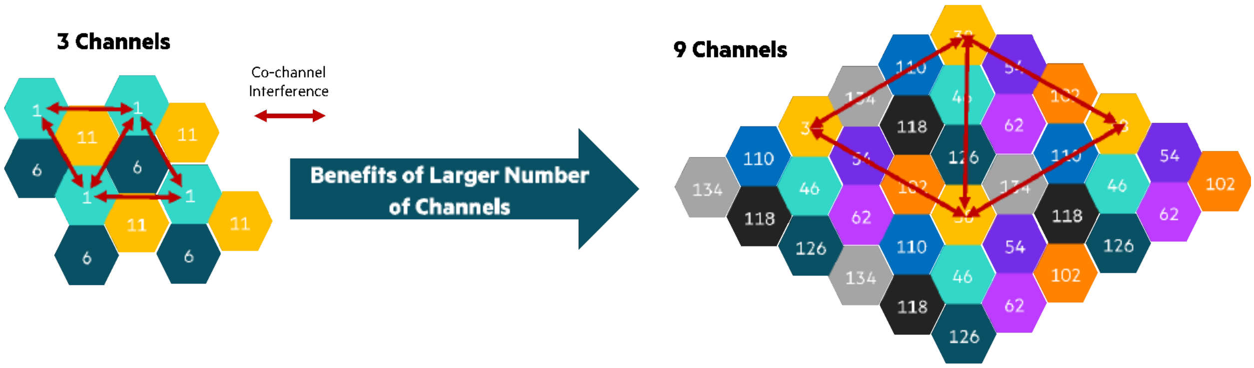


Figure 4 Inter-Cell distance increases with available channel count

b) <u>The 6 GHz band does not need to support any legacy Wi-Fi technology.</u>

Wi-Fi technology is backward compatible with previous generations. Legacy devices like Wi-Fi 4 and 5 can work together with devices supporting the latest Wi-Fi 6 standard. However, this backward compatibility can decrease the network performance, as the technology features provided by the latest Wi-Fi standard cannot be realised with legacy devices in the same network. The 6 GHz band would, for the first time, eliminate outdated and inefficient radio access technologies, permitting the far more spectrally efficient Wi-Fi 6E (and above) to operate without the burden of legacy radio interoperability. This will improve the user experience and spectral efficiency, which can only serve to further the adoption of Wi-Fi technologies.

[Editor’s note: To review based on input contributions]

5.2 SparkLink – Towards Next Generation Short Range Connectivity for Future Intelligent connected world

The trend towards wirelessness is gradually extending from traditional communications and electronics to various emerging areas. Long cables are dropped and unnecessary renovations are reduced. There is no physical disruption to existing devices, houses or the complex operation of deploying cables. Instead, all possible connected devices, terminals, everything, using high-speed, low-latency, stable and reliable wireless transmission.

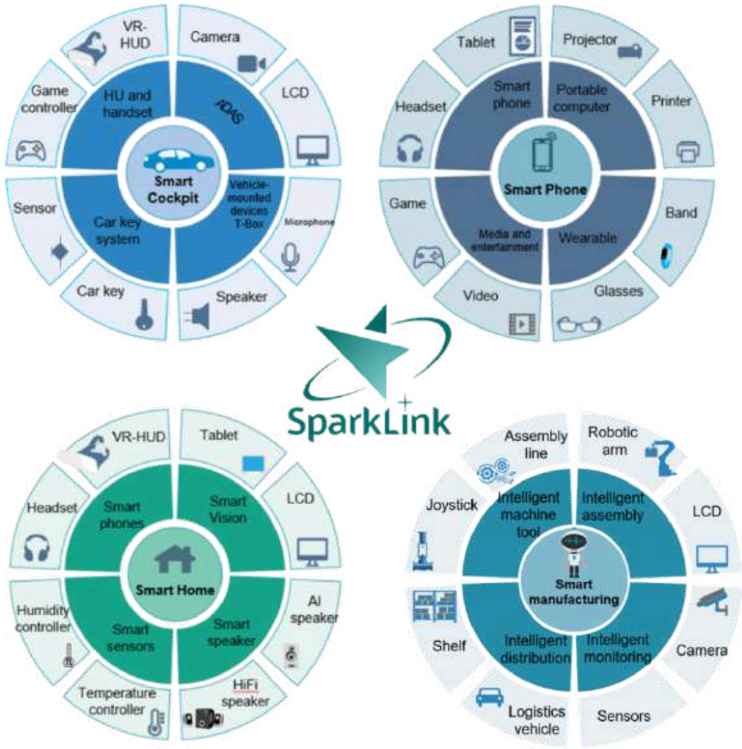


Figure 9 Application scenarios of SparkLink

In the smart cockpit of the future, there will be more and more wirelessly-enabled connections to drive screens, microphones and cameras to work. The various types of furniture in the home will use high-precision wireless control to do their job. Curtains will automatically open when the floor sweeper walks across the floor to prevent being rolled into the machine. The colour of the ambient light will change according to the position of you and your phone, creating a better home experience. Machinery and equipment in factories are free to be controlled precisely by wireless signals, working in tandem with sensors to be efficient and stable. These are all great ideas for the future, but they also pose serious challenges to existing wireless technologies. The SparkLink technology is dedicated to this, offering a new wireless connectivity experience. This technology is capable of providing ultra-low latency, ultra-high speed, ultra-reliable and ultra-precisely synchronized wireless transmission to provide better short-range wireless connectivity for smart cockpits, smart homes, smart terminals and smart manufacturing, especially in case of dense deployed scenarios. This technology is developed by SparkLink Alliance, which is an initiative of communications manufacturers, vehicle manufacturers, module manufacturers, chip manufacturers and application providers.

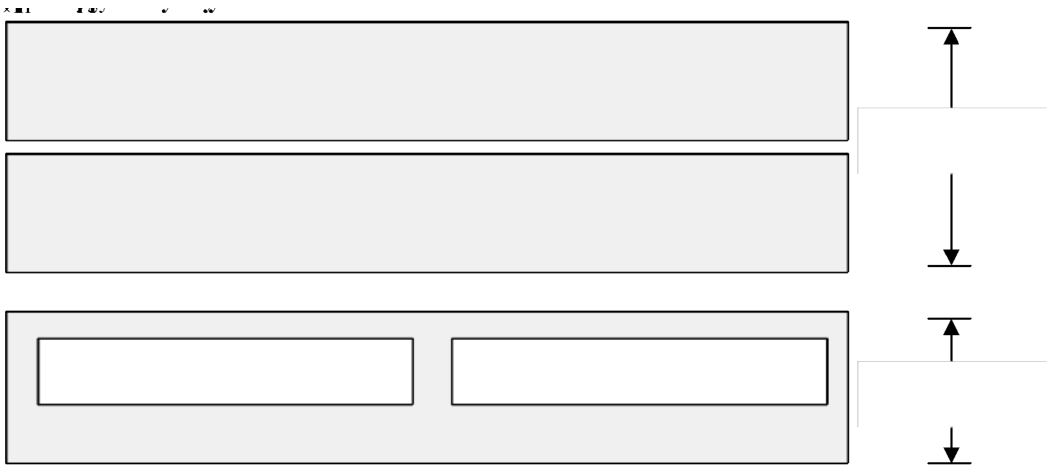


Figure 10 SparkLink Wireless Communication System

The SparkLink wireless communication system consists of the basic application layer, basic service layer, and access layer. The basic service layer provides a modular service for supporting an upper-layer service by defining different functional units, so as to meet the connection and interaction requirements of the E2E service processing (from service triggering to service termination). The access layer provides two transmission modes. One is SparkLink-Basic (SLB), which provides 20MHz to 320MHz wideband transmission capability, using OFDMA and site-to-site synchronized mechanisms and other advanced technologies. The other one is SparkLink Low Energy (SLE), which provides up to 12Mbps transmission date rates with up to 4MHz bandwidth support. SparkLink is capable of providing multiple access services of data transfer, which the data of a traffic flow is carried over multiple logical channels at the access layer. It includes duplicate transmission, split transmission, transmission switching from SLB to SLE, and transmission switching from SLE to SLB.

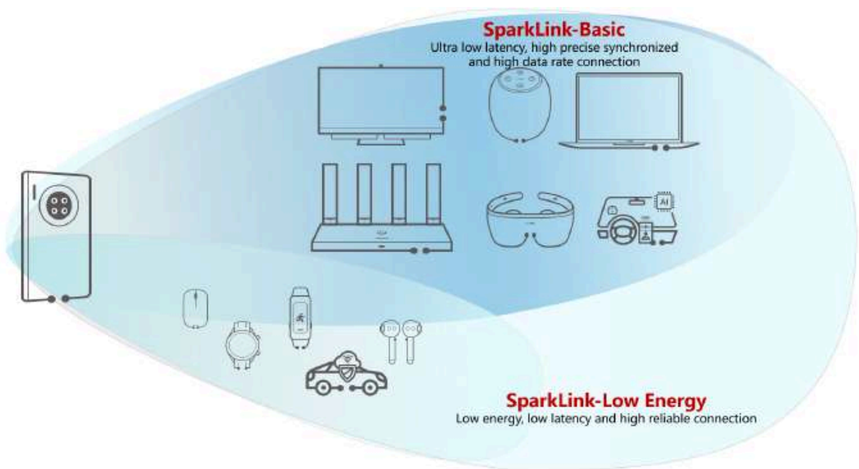


Figure 11 SparkLink Technology Family

With such capabilities, it is expected that SparkLink can contribute to build the future intelligent connected world.

5.3 Advancements in 5G New Radio Unlicensed (NR-U)

The groundwork for deploying 5G New Radio (NR) in unlicensed spectrum, referred to as NR-U, began with 3GPP Release 16. Following Release 16, more recent Releases 17 and 18 have further refined NR-U functionalities. They have integrated features such as NR-U downlink/uplink channel occupancy reporting to support data collection for NR

Self-Organizing Networks (SON) features [13]. Additionally, new deployment options for SON are introduced, including non-public (private) networks, expanding deployment possibilities within the 5G landscape.

Furthermore, 3GPP Release 17 ensures that NR-U defined procedures for operation in unlicensed spectrum will also apply to the unlicensed 60 GHz band. Specifically, NR-U operation in the 52.6 GHz to 71 GHz range can occur either in stand-alone mode or aggregated via carrier aggregation (CA) or dual connectivity (DC) with an anchor carrier, utilizing the existing NR downlink/uplink waveforms to accommodate new licensed and unlicensed frequency bands within this spectrum. However, operating within these bands does impact various aspects of the NR radio, including signal phase noise characteristics, transmitter linearity, power efficiency, and receiver noise figure, among others. Nevertheless, 3GPP has validated that implementing new advanced phase noise cancellation algorithms will sufficiently strengthen the physical layer, including the existing phase tracking reference signal and a sub-carrier spacing of 120 kHz, to support this extended frequency range. Moreover, an increased sub-carrier spacing of up to 960 kHz has been specified, enabling 3GPP to leverage even wider carriers of up to 2 GHz, consequently expanding the range of achievable data rates [14].

5.3.2 Channel and Spectrum usage of 3GPP technologies

[Editor's note: Consider adding 3GPP band information]

[

Wireless Access Systems (WAS) are defined as end-user radio connections to public or private core networks. Technologies in use today for implementing wireless access include cellular, cordless telecommunication, and wireless local area network systems.
WAS typically uses cellular radio frequencies and protocols such as GSM, CDMA or LTE to provide wireless connectivity to devices, and it is often used in mobile phones, tablets, and other mobile devices.

Wireless Access Systems (WAS) are defined as end-user radio connections to public or private core networks. Technologies in use today for implementing wireless access include cellular, cordless telecommunication, and wireless local area network systems.

The basic operation of WAS involves a network of base stations, or cell sites, that are strategically located to provide coverage over a particular area. Each cell site is equipped with one or more antennas that transmit and receive wireless signals to and from mobile devices within the coverage area.

When a mobile device wants to connect to the cellular network, it searches for an available cell site and sends a signal requesting access. The cell site authenticates the device and assigns it a unique identifier, such as a mobile phone number or subscriber identity module (SIM) card. Once the device is connected, it can communicate with other devices on the network and access the Internet or other network services. The wireless signals are encoded and modulated using various techniques to ensure reliable and secure communication.

The WAS network can be secured using various encryption and authentication protocols, such as Advanced Encryption Standard (AES) and Transport Layer Security (TLS). These protocols provide protection against unauthorized access and ensure the confidentiality and integrity of the data transmitted over the network.

WAS uses different wireless protocols and frequencies, depending on the technology used by the cellular network operator. For example, in case of GSM (Global System for Mobile Communications) standard, it uses a combination of time division multiple access (TDMA) and frequency division multiple access (FDMA) to divide the wireless spectrum into channels that can be shared by multiple users.

Overall, WAS provides a convenient and reliable way for mobile devices to connect and communicate over a wireless network, and it is widely used in cellular networks around the world.

Channel assignment in WAS (Wireless Access System) is the process of assigning frequencies or channels to different base stations, or cell sites, in a cellular network to avoid interference and ensure efficient use of the available wireless spectrum. The goal of channel assignment is to minimize the number of channels used while ensuring that each cell site has sufficient channels to serve its users. This is because the wireless spectrum is a limited resource, and it must be shared among all the cell sites in the network.

There are different channel assignment strategies that can be used in WAS, depending on the technology used by the cellular network operator. One common approach is the fixed channel allocation (FCA) strategy, where a fixed set of channels is assigned to each cell site, and the channels are reused across the network.
Another approach is the dynamic channel allocation (DCA) strategy, where channels are dynamically allocated to cell sites based on the traffic load and channel availability. This approach can help to optimize the use of the available spectrum and improve network efficiency.

In WAS, channel assignment can also be influenced by other factors such as the physical environment, the distance between cell sites, and the number of users in a particular area. In urban areas with high user density, for example, smaller cell sites may be used to provide better coverage and capacity, and more channels may be assigned to these sites to accommodate the higher traffic.

Overall, channel assignment is a critical aspect of WAS network design and optimization, and it requires careful planning and management to ensure optimal network performance and user experience.

]

6 Use cases for WAS/RLAN

With numerous 320 MHz channels, Wi-Fi 7 delivers the fastest WAS/RLAN ever, enabling multi-gigabit low latency connections. These high throughput connections are essential to support key use cases today and into the future.

Multi-gigabit WAS/RLAN venue capacity

Wide spectrum (e.g., 6 GHz) allows for a large number of wide band channels. This can help to avoid the excessive collisions and contention for airtime that has become normal in these types of venues. For instance, the Chase Center seats 18064 fans of the National Basketball Association’s Golden State Warriors. The arena also hosts concerts, comedians and other events. The Chase Center has hosted numerous sold-out events since its opening in 2019, including every Warriors game and the 2022 NBA Finals, which saw a peak of over 3.80 TB in use, with over 10000 unique devices. While hosting the 2022 NCAA Western Regional, the arena experienced a peak of over 4.05 TB.

Prior to the start of the 2022-2023 NBA season, the Chase Center deployed more than 250 Wi-Fi 6E APs to provide comprehensive Wi-Fi coverage across the arena. The installation will provide fans a more immersive experience.

Industrial and campus network

Because of their inherent features like flexibility, scalability, low latency, deterministic throughput, and ease of installation, Wi-Fi 6E and Wi-Fi 7 will be foundational connectivity enablers of Industry 4.0. They will be utilized for direct control of machines and other industrial appliances. Managing and monitoring of the rapidly reconfigurable, connected factories will become a reality.

The Health Care sector will also realize significant advancements from Wi-Fi 6E and Wi-Fi 7. With the introduction of the wide channel, guest traffic and enterprise traffic can be carried on different radios and on different channels. Thus, high priority clinical network traffic is not impeded by competing general use traffic – such as guest Internet access. High capacity and low latency Wi-Fi 6E/7 will act as enablers of Advanced Medical tools, devices and smart medical wearables. Monitoring and managing hospitals using these digital technologies, will become more accurate, faster and more reliable.

Public Transport system, high density client devices environment

The transport sector will certainly experience massive improvements in connectivity after the deployment of WAS/RLAN in thewide channel. This is evidenced by the recent WAS/RLAN network upgrade in Seoul. The average WAS/RLAN speed on Seoul subway trains was 71 Mbps, which is significantly lower than the download speeds in Seoul's subway stations, where commuters can expect a blistering 367 Mbps download speed. In 2022, the mobile carriers in the Republic of Korea installed Wi-Fi 6E routers on board the subway trains, together with mmWave base stations along the tracks for Wi-Fi 6E backhaul and ten mmWave customer premises equipment (CPE) on the trains themselves. According to the Ministry of Science and ICT, with the introduction of Wi-Fi 6E, subway commuters will have a more reliable internet connection, with speeds 10 times faster than the previous WAS/RLAN.

Low-latency WAS/RLAN calling, video conference and Augmented Reality /Virtual Reality (AR/VR)

Low latency is key to seamless experiences in real-time applications like videoconferencing and gaming. The wideband channels band will enable time-sensitive services like high definition audio and video conferencing. It will also support technologies like Virtual Reality, Cloud Gaming and Interactive Applications.

Today, AR and VR are changing both businesses functions and personal entertainment. From education and ecommerce to healthcare and construction, AR/VR can help to reduce training and operational costs and improve the productivity of workers and students.

AR/VR applications require high throughput and sub 10ms levels of latency. A delay in transmission/reception can cause problems for many, including desynchronization between connected devices that can disrupt the expected behaviour. These performance requirement will only be achieved with multiple wideband WAS/RLAN channels. [Academic analysis shows the significance of 1200 MHz of spectrum availability for supporting AR/VR applications in high-density large-scale scenarios and that 500 MHz of spectrum is not enough to support AR/VR applications[5][6].]

Rural connectivity

WAS/RLAN is one of the most economical and fastest ways to provide connectivity in rural areas. The operation in license-exempt frequency bands, higher data rates, ease and lower cost of deployment, and lower operational and maintenance costs are key factors driving the deployment of WAS/RLAN and proprietary license-exempt technologies in rural areas around the world.

A high-capacity data link can be established to a central point with a fiber point of presence, a satellite link or a microwave point-to-point backhaul. The point-to-point backhaul may be in-band using the License Exempt 6GHz frequency. This data link could then be reticulated throughout the township via Wi-Fi, delivering the same quality of service experienced in metropolitan areas. This method of broadband access is particularly helpful for remote towns/villages and low-income communities, where there is an acute need for broadband access but not a large enough market to justify licensed spectrum or wired solutions.

Industrial and campus network

Additionally, numerous industrial applications rely heavily on time-sensitive networking (TSN) due to its guaranteed low latency. 5G provides a standardized framework to integrate existing TSN networks. Additionally, several other 5G features beneficial for Industrial Internet of Things (IIoT), such as synchronized sharing, multiple transmission and reception points (multi-TRP) with coordinated multi-point transmissions (CoMP), and enhanced ultra-reliable low-latency communications (eURLLC), can be implemented alongside NR-U.

7 Spectrum considerations for WAS/RLAN networks.

7.1 Spectrum and Regulatory Aspects of WAS/RLAN networks

[Editor's note: Same text also in Introduction Section 1]
[The demand for wireless broadband is increasing at a phenomenal pace, as citizens and businesses groups are increasingly relying on Internet connectivity. To meet this demand, the various administrations are continuously evaluating the use of the spectrum available for the use of WAS/RLAN in more efficient usage using a variety of methods, including unlicensed operations.]

Considering the existing and anticipated congestion, many administrations decided to provide additional spectrum to complement spectrum where Wi-Fi is presently deployed, to ease any congestion so that businesses and consumers can take advantage of new data intensive

[5] M. Mehrnoush, C. Hu and C. Aldana, "AR/VR Spectrum Requirement for Wi-Fi 6E and Beyond," in IEEE Access, vol. 10, pp. 133016-133026, 2022, doi: 10.1109/ACCESS.2022.3231229.

[6] https://www.intel.com/content/www/us/en/wireless-network/spectrum-needs-of-wi-fi-7.html

applications. By making this spectrum available for unlicensed use, cable companies and wireless carriers started expanding their Wi-Fi hotspot networks to provide customers' access to even higher speed data connections, than they experience today and expand their networks in areas where they need additional capacity.

A study by Wi-Fi Alliance in 2017 showed that in order to maintain desired levels of performance, 1.5 GHz of new spectrum would be needed by 2025. Recognizing that lack of spectrum access threatens Wi-Fi's critical role to their countries' futures, policymakers are expanding spectrum access for Wi-Fi with a particular focus on the 6 GHz band (5.925 – 7.125 GHz). At WRC-23, footnote 5.6A12 was also added to recognize the unlicensed RLAN use of 6.425 – 7.125 GHz.

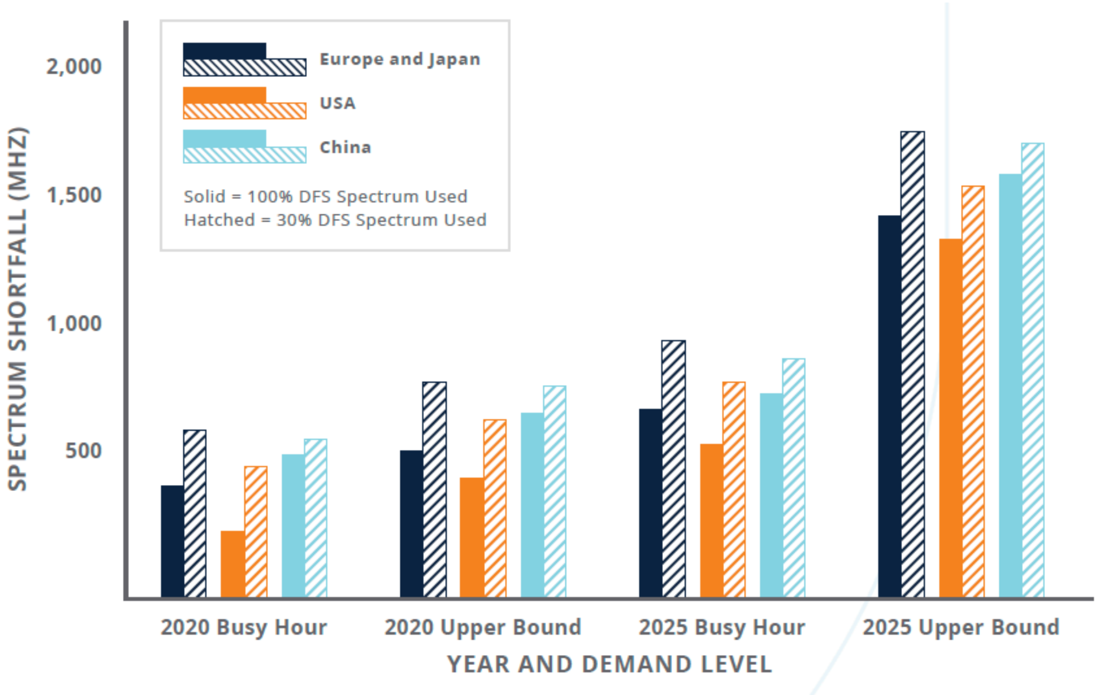


Figure 1 Predicted Wi-Fi spectrum shortfall[7]

7.1.1 Making more efficient use of spectrum in the 5 GHz band

WAS/RLAN use is currently accessing 580 MHz of license-exempt spectrum in the 5 GHz band. Some of the available channels either have Dynamic Frequency Selection (DFS) requirements to protect military and meteorological radars in these frequencies, or are limited to indoor use only.

[Editor's Note: include other 5 GHz bands to give full picture; also cover APT countries and better structure; use response]

[7] Source: Quotient Associates for the Wi-Fi Alliance, 2017

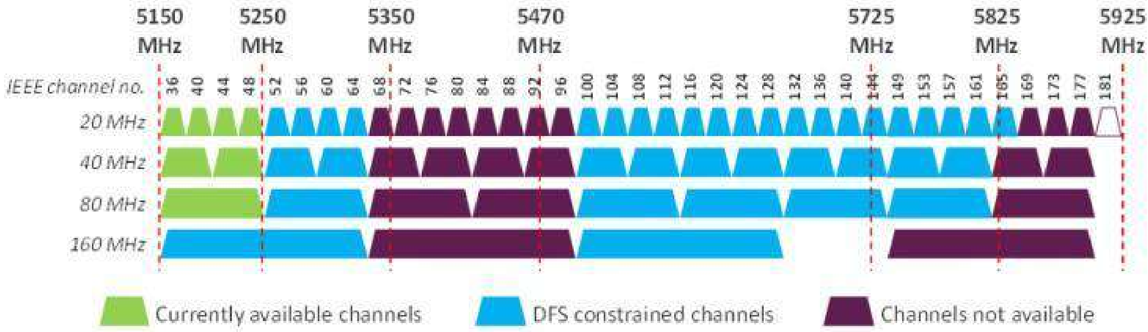


Figure 2 WAS/RLAN channels in the 5 GHz band

At the World Radiocommunications Conference 2019 (WRC-19), the Radio Regulations were amended to allow limited outdoor WAS/RLAN use in the 5.15 – 5.25 GHz band: up to 1W with controlled use and by implementing antenna elevation masks that limit EIRP in the direction of satellite space stations.

Resolution-229 (WRC-19)[8] provides guidance for administrators who want to deploy higher-power outdoor WAS/RLAN services in 5.15 – 5.25 GHz. This *Resolve* gives administrations flexibility to permit WAS/RLAN stations, for indoor or controlled outdoor use, to operate up to a maximum EIRP of 30 dBm, while also mitigating the interference risk to Fixed Satellite Service (FSS) Earth-to-space communications with an EIPR mask at certain elevation angles.

[Many administrations implemented Resolution-229. For instance,][The]New Zealand regulator Radio Spectrum Management (RSM) updated its General User License for Short Range Device[9] in 2020 by allowing 1W EIRP and removed the indoor restriction on use of the 5.15 – 5.25 GHz under certain technical conditions. Similarly, Australia Communications and Media Authority (ACMA) consulted the industry in 2022 for its proposal in implementing this Resolution. ACMA proposed to allow 1W EIRP and outdoor use, as well as mandating an emission mask of a maximum of 125 mW (21 dBm) EIRP at any elevation angle above 30 degrees, as measured from the horizon[10].

[

Table 1 Regulatory requirement for RLAN operating in 5.15 – 5.35 GHz

Country	Regulatory requirement
US	1W maximum conducted power and maximum antenna gain 6 dBi, maximum power spectral density 17dBm/MHz; Maximum EIRP at any elevation angle above 30 degrees as measured from the horizon must not exceed 125 mW (21 dBm); Allows point to point system with 23dBi antenna gain
Canada	1W maximum conducted power and maximum antenna gain 6 dBi, maximum power spectral density 17dBm/MHz; Maximum EIRP at any elevation angle above 30 degrees as measured from the horizon must not exceed 125 mW (21 dBm); Allows point to point system with 23dBi antenna gain

8 https://www.itu.int/dms_pub/itu-r/oth/0C/0A/R0C0A00000F0076PDFE.pdf
9 https://gazette.govt.nz/notice/id/2022-go3100
10 https://www.acma.gov.au/consultations/2022-10/new-arrangements-low-interference-potential-devices-consultation-352022

New Zealand	1W maximum EIRP; EIRP mask[11] for elevation above horizon when operating above -7 dBW (200 mW) EIRP;
Australia	5.15 – 5.25 GHz (indoor and outdoor) 1W maximum EIRP; Maximum EIRP at any elevation angle above 30 degrees as measured from the horizon must not exceed 125 mW (21 dBm); 5.15 – 5.25 GHz (indoor only) 200mW maximum EIRP; 10 mW EIRP/MHz for b/w ≥ 1 MHz; 40µW EIRP/4 kHz for b/w < 1 MHz 5.25 – 5.35 GHz (indoor only) 200 mW maximum EIRP; 10 mW EIRP/MHz for b/w ≥ 1 MHz; 40µW EIRP/4 kHz for b/w < 1 MHz The transmitter must use Dynamic Frequency Selection (DFS). If the maximum EIRP is greater than 100 mW, the transmitter must use Transmit Power Control (TPC).
Japan	For 5.15 -5.25 GHz, 1W maximum EIRP; EIRP mask for elevation above the horizon; Registration is required for access points for outdoor use or with a maximum EIRP greater than 200mW; 40mW maximum EIRP inside automobiles
Korea	The conducted power and spectral density is varied from 1.25 mW/MHz to 10 mW/MHz according to occupied bandwidth (0.5 MHz - – 160 MHz) and maximum antenna gain 7 dBi. Maximum 1 W/MHz EIRP shall be met in all cases. In the frequency bands of 5150 - 5350 and 5470 - – 5850 MHz, multiple 80 MHz bandwidth can be grouped continuously or discontinuously to form a single channel with a maximum occupied bandwidth of 160 MHz. In this case, the antenna power density should be less or equal to 1.25 mW/MHz.

]

For 5725 - 5850 MHz, many regulators have decided that there is little risk of interference from indoor use of WAS/RLAN in the frequency to incumbent radar systems and are relaxing or removing the DFS requirements. For instance, in 2020 Ofcom UK removed the DFS requirement for indoor WAS/RLAN operations up to 200 mW EIRP in the 5.8 GHz band.[12]

7.1.2 Equipment Classes for 6 GHz License-Exempt Operation

6 GHz devices achieve the best possible performance while ensuring that important licensed incumbent services are not adversely affected. These incumbent services include Fixed Service (FS) links and Fixed Satellite Service (FSS) uplinks. Wi-Fi 6E achieves this goal by defining three separate operating classes for Wi-Fi 6E access points: Low Power Indoor (LPI), Standard Power (SP), and Very Low Power (VLP). Client device technical characteristics are a function of the type of access point they are connected to.

[11] Resolve 5 of RESOLUTION 229 (REV.WRC-19)
[12] https://www.ofcom.org.uk/__data/assets/pdf_file/0036/198927/6ghz-statement.pdf

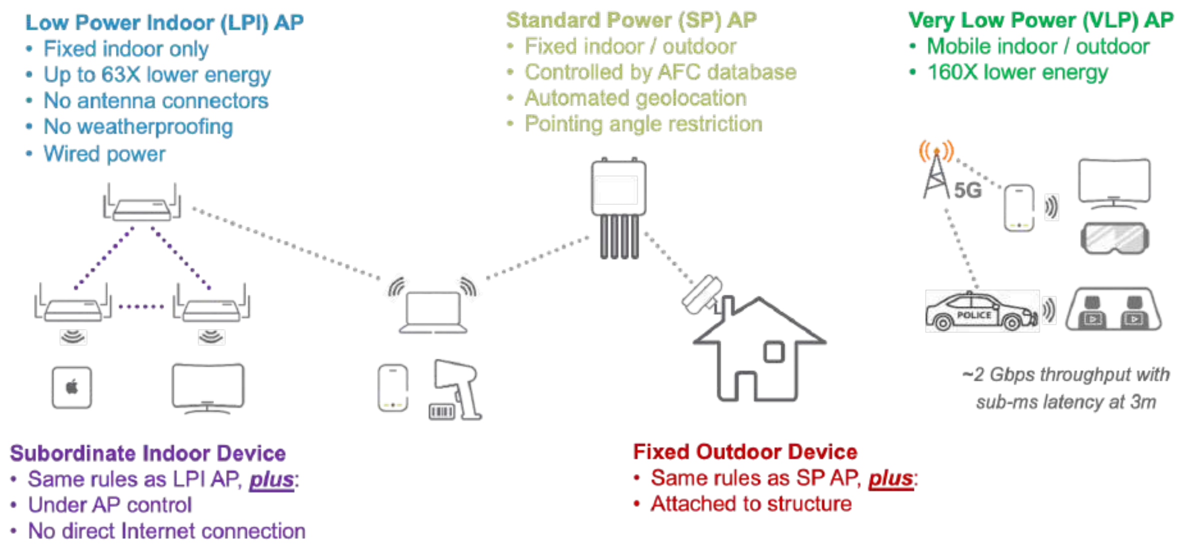


Figure 6 Device Classes in 6 GHz

Low Power Indoor Class

The most popularly used device class for Wi-Fi 6E is LPI. These will be the familiar home or enterprise APs and clients. By definition, these devices are indoors and are shielded by buildings to some extent so the power that leaks outside will be attenuated, which allows safe operation across the band at a power level only slightly lower than 5 GHz indoor Wi-Fi APs. Depending on the regulatory requirement, LPI equipment can operate at a maximum EIRP of 23 dBm, 24 dBm or 30 dBm and is often defined in terms of a Power Spectral Density (PSD) of dBm/MHz. LPI APs can operate across the entire 6 GHz band, as their low EIRP is not posing any harmful interference to incumbents after building entry loss is subtracted. To ensure that these indoor-only units are not used outdoors, or with external high-gain antennas (which has the potential to cause interference), regulators typically provide a list of physical requirements for certifying an LPI AP:

- No connectors for external antennas
- No battery-powered operation
- Not weatherized
- Labeled for indoor use only

To further improve spectral efficiency and performance, direct communication between client devices (Client to Client) communications are also authorized by some regulators and under consideration by others.

Standard Power Class

The EIRP of a Standard Power AP is up to 36 dBm. Because of the increased risk of interference with incumbent services from a higher EIRP, there are certain regulatory requirements for SP APs to operate. First, depending on the incumbent service types, SP APs are only allowed to operate in the certain frequency ranges within the overall 6 GHz band. Secondly, operation of SP requires an Automatic Frequency Coordination (AFC) service to calculate the channel availability and allowed EIRP at a specific location.

The AFC query-response protocol has been defined by the Wi-Fi Alliance[13] and consists of an inquiry message from the AP and a response from the AFC server. An important information element in the inquiry is the AP's geolocation. There is no single method to accurately determine the AP's location; it is assumed that GPS or some other robust and reliable method is used. The AFC uses the AP's latitude, longitude, antenna height (above ground level) and some other information in the registration and inquiry messages, to calculate and provide to the AP a response containing the set of channels or frequency ranges and the maximum permissible power levels at which it may transmit without creating interference to nearby incumbent services.

In the US, FCC is considering [14]direct communication between client devices (Client to Client) communications within Standard Power mode coverage area.

Very Low Power Class

VLP devices can operate both indoor and outdoor in the whole 6 GHz range. This allows use cases like mobile APs, mounted in vehicles or hotspots on smartphones. In most countries and regions, the maximum EIRP for a VLP AP is 14 dBm, with a PSD limit of 1dBm/MHz.

Client Devices

Client devices are expected to be limited in geography by APs. If there is no AP signal, devices cannot connect and will not transmit. Therefore, it is assumed that the AP is transmitting in an authorized manner, and the client can adjust its transmit power and channel with reference to the AP.

7.1.3 Technical Conditions regarding use Wi-Fi in 6 GHz band:
[China Editor's note: moved to section 4.]

Initially Wi-Fi networks operates in the unlicensed 2.4 GHz and later unlicensed 5 GHz bands was also open for Wi-Fi. The 2.4-GHz band works the best for indoor Wi-Fi use, as easily penetrates through walls and furniture, and signals generally travel farther at the same power level as they do in the 5-GHz band.

In the 2.4 GHz band, roughly 80 MHz frequency band is available for the Wi-Fi use. The channels are 20 or 22 MHz wide, so normally three nonoverlapping channels are existing. The situation is slightly different in Europe, where 13 channels are allowed, but still just three nonoverlapping channels, In Japan, there are 14 channels with four nonoverlapping channels.

Signals in the 5-GHz band have a shorter range in the home, mostly because of the walls and furniture, but the band extends from 5.125 to 5.925 GHz (800 MHz), so 24 non-overlapping channel of 20MHz-wide each or 12 channels of 40 MHz wide or 6 channels of 80 MHz or 2 channels of 160 MHz wide channels can work.

In the Wi-Fi world, when two conversations collide, all the devices go quiet and then try to talk again a little while later. The amount of time they wait is determined by an exponentially increasing time delay, known as a backoff. With more collisions, the backoff increases, and the

[13] https://www.wi-fi.org/file/afc-specification-and-test-plans
[14] DA-21-7A1_Rcd.pdf (fcc.gov)

Wi-Fi becomes slower and less reliable. Today, congestion has increased so much in many regions making 2.4 GHz band unusable for transferring data at high rates.

Wi-Fi congestion may go even worse, as the mobile-phone carriers are planning to use the technology called as LTE-Unlicensed (LTE-U) or Licensed Assisted Access (LAA). It uses 4G LTE radios and routers to send and receive data via the same 5 GHz frequencies as used by unlicensed Wi-Fi.

So, to overcome the problem, many administrations allowed entire 6 GHz band from 5925 -7125 MHz band for the use of unlicensed Wi-Fi, with two types of operation.

(a) Authorizing unlicensed standard-power access points in the band 5925-6875 MHz, through use of an AFC system. The AFC is designed to protect devices with fixed locations.
(b) Opening the entire 6 GHz band for unlicensed indoor low power access points. By authorizing use of the entire 6 GHz band for indoor use, so 59 channels of 20 MHz or 29 channels of 40 MHz or 14 channels of 80 MHz or 7 channels of 160 MHz channels or 3 channels of 320 MHz are possible to expand capacity and performance capabilities.

So, the 6 GHz Wi-Fi or Wi-Fi 6E extends the same Wi-Fi capabilities into the 6 GHz band to allow greater efficiency, higher throughput, and increased security. 6 GHz Wi-Fi is specifically designed for gigabit broadband and immersive wireless applications. Considering the vast capabilities Wi-Fi 6E, many countries around the World have already delicensed 6 GHz band for Wi-Fi.

[

7.1.4 Technical conditions for authorising WAS/RLAN in the 6 GHz frequency band

When making 6 GHz frequency band available for WAS/RLAN under a general authorisation / licence exemption / unlicensed regimes technical conditions need to be applied for coexistence with existing radio systems, particularly fixed links. There are different options that have been applied by regulators and regions these options are contained below.

]

]

7.2 Regulatory information [in APT Region]

[Editor's note: Some admins propose to keep only APT region information in this section. Outside APT region information proposed to be in a different sub-section or Annex]

7.2.1 Regulatory information in APT Region

Australia

In 2022, ACMA updated the LIPD class license arrangements to support RLANs in the 5925 – 6425 MHz range as the first stage of its 6 GHz band planning. The devices operating within that frequency range are allowed to operate at two different power limits: 24 dBm (11 dBm/MHz), if only used indoors or 14 dBm (1 dBm/MHz) in all locations.

Korea (Rep. of)

In the Republic of Korea, the whole 6 GHz band is authorised for unlicensed RLAN use. The use includes two device classes: low power indoor use – maximum 24 dBm and 2 dBm/MHz, and very low power (14 dBm) devices were also included but limited to operate in the lower 6 GHz band. Republic of Korea has also stated their intention to authorize Client to Client mode and Standard Power in conjunction with a Korean Frequency Coordination system in the future.

The conducted power and spectral density is varied from 1.25 mW/MHz to 10 mW/MHz according to occupied bandwidth (0.5 MHz – 160 MHz) and maximum antenna gain 7 dBi. Maximum 1 W/MHz EIRP shall be met in all cases. In the frequency bands of 5150-5350 and 5470 – 5850 MHz, multiple 80 MHz bandwidth can be grouped continuously or discontinuously to form a single channel with a maximum occupied bandwidth of 160 MHz. In this case, the antenna power density should be less or equal to 1.25 mW/MHz.

New Zealand

In 2022, Radio Spectrum Management made available the 5 925 – 6 425 MHz frequency band for WAS/RLAN under a general authorisation / licence exemption / unlicensed regimes and applied particular technical conditions. A summary of the technical conditions applied in New Zealand can be found in Table 1 with full requirements available in our Radiocommunications Regulations (General User Radio License for Short Range Devices) Notice 2022[15].

Table 1: Summary of technical conditions for 6 GHz WAS/RLAN

Permitted frequency band	Category	Max Power (EIRP)	Max. Power Density (EIRP)	Conditions
5925 – 6425 MHz	Low Power Indoor (LPI)	24 dBm (250 mW)	11 dBm / MHz (12.6 mW /MHz)	Indoor use only within a building or within an enclosed space having attenuation characteristics at least equivalent to those of a building
	Very Low Power (VLP)	14 dBm (25.11 mW)	1 dBm / MHz (1.26 mW / MHz)	No indoor restriction (i.e. Outdoor is permitted)
Applicable Standard: See https://www.rsm.govt.nz/about/publications/gazette-notices/product-compliance-gazette-notices/				

China

In china, the band 2400-2483.5MHz, 5150-5350MHz and 5725-5850MHz are authorized for WAS/RLAN use. 2400-2483.5MHz and 5725-5850MHz could be used both indoor and outdoor. 5150-5350MHz could be used only indoor. Maximum EIRP of device in

[15] https://www.rsm.govt.nz/licensing/frequencies-for-anyone/short-range-devices-gurl/

2400-2483.5MHz is 27dBm. Maximum EIRP of device in 5150-5350MHz MHz is 23dBm. Maximum EIRP of device in 5725-5850MHz is 33dBm

Japan

In September 2022, the national regulation of Japan was revised to allow license-exempt LPI and VLP operations in the 5925-6425 MHz frequency band. The 6425-7125 MHz frequency band is under technical study.

[Editor's note: to consider if this information remains in a sub-section here or in Annex]

7.2.2 Regulatory information from outside APT Region

Brazil

In Brazil, the whole 6 GHz band (5925 – 7125 MHz) available for license-exempt RLAN use, which includes two device classes: LPI (30 dBm) and VLP (17 dBm) devices. Brazil Anatel is currently working on enabling SP mode under supervision of AFC System.

Canada

Canada allows license-exempt RLAN use across the entire 6 GHz, with 3 different power levels available across different portions of that range:

- 14 dBm "very low power"
- 30 dBm "low power" for indoor use only
- 36 dBm for standard power devices under AFC control.

The AFC is to be compatible – as much as possible – with the US version, to help deal with cross-border coordination.

"Listen-before-talk" protocols are to be implemented on all low and very-low power devices. SP APs under the control of an AFC system will be permitted to operate on a license-exempt basis in the 5925 – 6875 MHz frequency range. For the protection of FSS satellite-based receivers from Standard Power devices operating outdoors, the SP APs' maximum EIRP must be under 125 mW at elevation angles above 30 degrees above the horizon – consistent with Canada's experience in other bands.

United States

The Federal Communications Commission (FCC) made the entire 6 GHz band (5925 – 7125 MHz) for Wi-Fi 6E and other unlicensed uses in the US in April 2020.
The FCC authorizes indoor low-power operations over the full 1200 MHz and Standard Power devices in 850 MHz of the 6 GHz band (the other ranges being excluded due to the presence of mobile incumbent services). The FCC requires the SP APs to use an AFC[16] to prevent interference to incumbent services.
For Standard Power outdoor use, the maximum EIRP at any elevation angle above 30 degrees as measured from the horizon must not exceed 21 dBm.

[16] Federal Register, Unlicensed Use of the 6 GHz Band

Table 2 Maximum EIRP for 6 GHz unlicensed devices in the US

Devices Class	Operating bands	Maximum EIRP	Maximum EIRP Power Spectral Density
Standard-Power AP (AFC controlled)	U-NII-5 (5925 - 6425 MHz) U-NII-7 (6525 - 6875 MHz)	36 dBm	23 dBm/MHz
Client Connected to Standard-Power AP		30 dBm	17 dBm/MHz
Low-Power (indoor only)	U-NII-5 (5925 - 6425 MHz) U-NII-6 (6425 - 6525 MHz) U-NII-7 (6525 - 6875 MHz) U-NII-8 (6875 - 7125 MHz)	30 dBm	5 dBm/MHz
Client Connected to Low-Power AP		24 dBm	-1 dBm/MHz

Europe

In 2020, Europe made a decision on[17] License Exempt LPI and VLP operation in the 5925 – 6425 MHz range and currently studying the 6425 – 7125 MHz range. The devices operating within that frequency range are allowed to operate at two different power limits: 23 dBm (10 dBm/MHz), if only used indoors or 14 dBm (1 dBm/MHz) in all locations. EU also harmonized the band for Client to Client operation under LPI mode.

ATU

In July of 2021, African Telecommunications Union (ATU) recommended License Exempt LPI and VLP operation in the 5925 – 6425 MHz range. The devices operating within that frequency range are allowed to operate at two different power limits: 23 dBm (10 dBm/MHz), if only used indoors or 14 dBm (1 dBm/MHz) in all locations.

Colombia

In Nov 2022, Colombia ANE announced[18] allocation of the entire 6GHz band (5925 –7125MHz) for License Exempt LPI operation at maximum power level of 30 and 24 dBm (5 and -1 dBm/MHz) for Access Point and Client devices respectively.

Argentina

In May 2023, Argentina Enacom announced[19] allocation of the entire 6GHz band (5925 –7125MHz) for License Exempt operation. Regulatory details are not announced yet.

Saudi Arabia

In March of 2021, Saudi Arabia allocated the entire 6GHz band (5925-7125MHz) for License Exempt LPI operation at maximum power level of 30 and 24 dBm (10 dBm/MHz) for Access Point and Client devices respectively. Work on SP and VLP modes are ongoing.

[17] https://docdb.cept.org/download/50365191-a99d/ECC%20Decision%20(20)01.pdf

[18] Wifi 6: Sergio Massa launched a program to improve Internet connectivity throughout the country - Infobae

[19] Wifi 6: Sergio Massa launched a program to improve Internet connectivity throughout the country - Infobae

[Editor's note: To review text, and keep it for information about WAS/RLAN usage and protection to incumbent services. This section text not to include information about revisiting or influencing WRC agenda items.]

[

7.3 Sharing with incumbent services in the 6 GHz band

The 5925 – 7125 MHz frequency range is primarily allocated to Fixed Service (FS), Fixed Satellite Service (FSS) and Mobile Service (MS). The 6650 – 6675 MHz frequency range is also used by the Radio Astronomy Service (RAS). Although there is no primary allocation, ITU Radio Regulation requires administration to protect RAS at 6650-6675.2 MHz in its footnote 5.149.

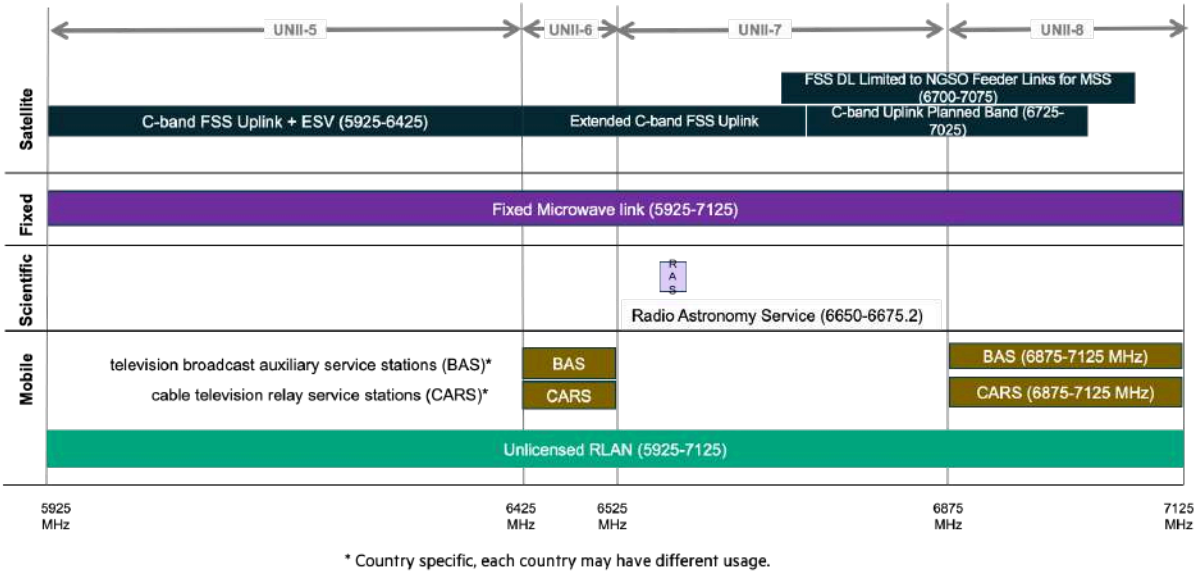


Figure 7 Current use of 5925 – 7125 MHz

For protecting FSS, studies showed interference to noise ratio (I/N) into FSS receivers was -21.9 dB, well below the applicable interference protection criteria (IPC) and significantly less than the interference FSS presently receives from existing FS microwave transmissions[20].

For protecting FS, various studies show LPI and VLP can co-exist with FS without presenting a significant risk of harmful interference. For SP operation, it requires the AFC to automatically (with frequent updates) coordinate license-exempt operations while protecting nearby FS receivers. AFC systems use the RLAN APs' locations and other information to calculate whether any of the FS incumbents in the regulatory licensing database might be affected and then returns to the SP APs the allowed power and frequency parameters.

[20] RKF Report - Frequency Sharing for Radio Local Area Networks in the 6 GHz Band

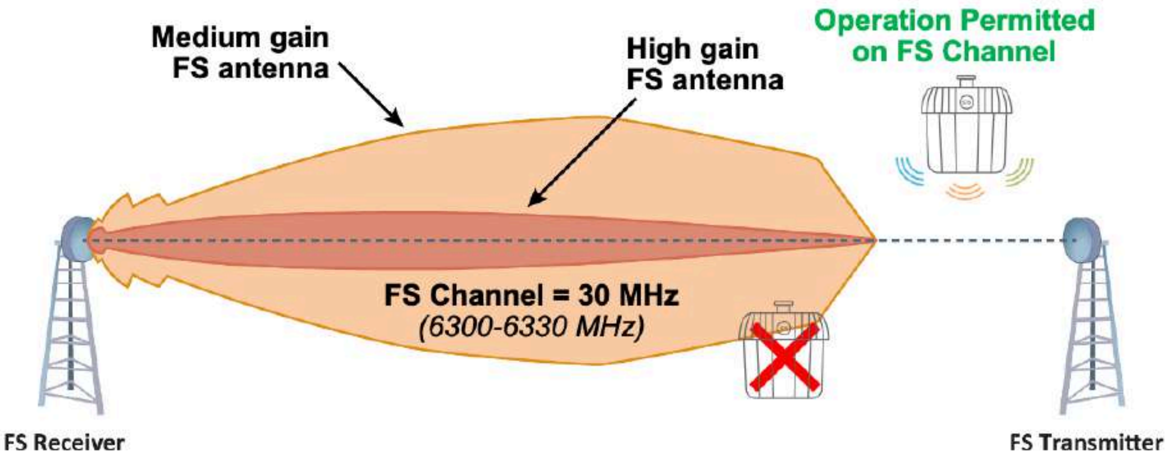


Figure 8 SP AP use AFC to coordinate with FS

For protecting RAS, an I/N threshold can be used to derive a contour around the RAS site following applicable ITU-R Recommendations[21] and taking into account the details of the site and possibly the typical observation schedule. The contours, which can be considered as a coordination zone or exclusion zone, represent a zone which needs to be managed by the regulator. Taking the FCC's requirement as an example, the exclusion zone sizes are based on the radio line-of-sight and determined using 4⁄3 earth curvature and the following formula:

$$dkm\_los = 4.12 * (sqrt(H_{tx}) + sqrt(H_{rx})),$$

where H_{tx} is the height of the license-exempt standard power access point or fixed client device and H_{rx} is the height of the radio astronomy antenna in meters above ground level.

The AFC will then exclude the RAS frequencies in its responses to SP APs located within the protection contour.

Depending on each country, portions of this band are also used for public safety and electronic news gathering applications such as TV Broadcast Auxiliary and Cable Relay Services, which are under Mobile Service type. These bands are less suited for Standard Power and AFC coordination because the usage patterns are more dynamic, so Standard Power is not allowed in these frequency ranges.

7.3.1 Usage of the 5925 – 7125 MHz spectrum

As per the Radio Regulation, 2020, 6 GHz has been allocated for the following services

S. No.	Frequency Band	Allocated on Primary basis	Region
1	5925 – 6700 MHz	FIXED, FIXED SATELLITE (Earth to space), MOBILE	Globally
2	6700 – 7075 MHz	FIXED,	Globally

[21] Recommendation ITU-R RA.769-2: "Protection criteria used for radio astronomical measurements"

		FIXED SATELLITE (Earth to space), MOBILE	
3.	7075 – 7125 MHz	FIXED, MOBILE	Globally

As per the results of WRC-23, the frequency bands 6425-7125 MHz in Region 1 and 7025-7125 MHz in Region 3 are identified for IMT, and the frequency band 6425-7025 or 6425-7125 MHz in some countries is identified for IMT on the basis of country footnotes applied to all regions.
In addition, texts on the implementation of WAS/RLANs are added in the Radio Regulations: "The frequency bands are also used for the implementation of wireless access systems (WAS), including radio local area networks (RLANs)."
[Editor's Note: WRC-27 Agenda Item 1.7 related text. May not be relevant to this report.]
[As per the decision taken in WRC-23 vide Agenda Item1.7 of WRC-27, ITU-R was requested to consider identification of the frequency bands 4400-4800 MHz, 7125-8400 MHz and 14.8-15.35 GHz for International Mobile Telecommunications (IMT), including possible additional allocations to the mobile service on a primary basis.

The following frequency bands were addressed under this agenda item:

– 4400-4800 MHz, or parts thereof, in Region 1 and Region 3;

– 7125-8400 MHz, or part thereof, in Region 2 and Region 3;

– 7125-7250 MHz and 7750-8400 MHz, or part thereof, in Region 1;

– 14.8-15.35 GHz,]

]

7.X.X New spectrum in 60GHz band

[Editor's Note: contribution are invited to introduce 60GHz band RLAN networks.]

8. Summary

WAS/RLAN is optimized for high performance indoor, and therefore delivers the bulk of the world's data traffic, including most data traffic on mobile devices. Demand for WAS/RLAN will continue to grow with increased fiber deployments and cellular generations.
[
Wi-Fi 6E is a resounding success and by 2024, there will be billions of devices installed globally able to operate from 5.925 to 7.125 GHz. Only countries that allow Wi-Fi access to the entire 6 GHz spectrum range will be most benefited.
Wi-Fi 7 and Wi-Fi 8 will depend on 6GHz access, and 320 MHz channels will be optimized for demanding emerging use cases.
6 GHz frequency band from 5925 – 7125 MHz is perfectly suited for Wi-Fi to continue to deliver the connectivity users need, there is no alternative spectrum for Wi-Fi, and 6 GHz is unsuitable for IMT.
As many countries in all regions are deploying Wi-Fi in 6 GHz, so 5G networks are not feasible in 6 GHz. Therefore, frequency harmonization for IMT/5G cannot be achieved in 6 GHz, even no interoperability. Market fragmentation precludes economies of scale, which is

necessary for a viable 5G ecosystem in 6 GHz, as massive investments are needed to design and produce cellular chipsets for 6 GHz, to integrate chipsets into devices and bring them to market, to deploy IMT technology network and to operate IMT network. At present, no ecosystem is available for the IMT in 6 GHz band nor likely to come in near future.
]

Furthermore, NR-U technology extends the capabilities of 5G NR to unlicensed spectrum. Particularly, standalone NR-U enables the deployment of high-performance 5G in private networks without the need for licensed spectrum. A NR-U network can be used for a variety of applications, including mission-critical sensing and control, video surveillance, augmented or virtual reality (XR), and voice. These applications may have distinct requirements regarding throughput, latency, and reliability.

Annex 1 : Technology features in IEEE 802.11ax and IEEE 802.11be

Technology features in IEEE 802.11ax and IEEE 802.11be

1. IEEE 802.11ax [(Wi-Fi 6/6E)]

[
IEEE 802.11ax, officially marketed by the Wi-Fi Alliance as Wi-Fi 6 (2.4 GHz and 5 GHz) and Wi-Fi 6E (6 GHz), is an IEEE standard for wireless local-area networks (WLANs) and the successor of 802.11ac. It is also known as High Efficiency Wi-Fi, for the overall improvements to Wi-Fi 6 clients in dense environments. The technology is designed to operate in license-exempt bands between 1 and 7.125 GHz, including the 2.4 and 5 GHz bands already in common use as well as the much wider 6 GHz band.
]

There are a number of features in IEEE 802.11ax with the main design goal to enhance throughput-per-area in high-density scenarios, such as corporate offices, shopping malls and dense residential apartments.

1.1 Downlink and uplink OFDMA

OFDMA is one of the more complex features in 802.11ax. It allows a single transmission (for downlink OFDMA, the access point transmits) to be split by frequency within a channel, such that different frames addressed to different client devices use groups of subcarriers. Uplink OFDMA is equivalent to downlink OFDMA, but in this case multiple client devices transmit simultaneously, on different groups of subcarriers within the same channel.

In 802.11ac, Wi-Fi channel was broken down into a collection of smaller OFDM sub-channels and at any given point in time, a single user is allocated all those sub-carriers in each PPDU. However, this allocation method does not provide the best spectrum efficiency as each data traffic may not necessarily require the full bandwidth to transmit. In 802.11ax OFDMA (802.11ax) is introduced to enhance the efficiency, individual groups of subcarriers are individually allocated to clients as resource units on a per-PPDU basis.

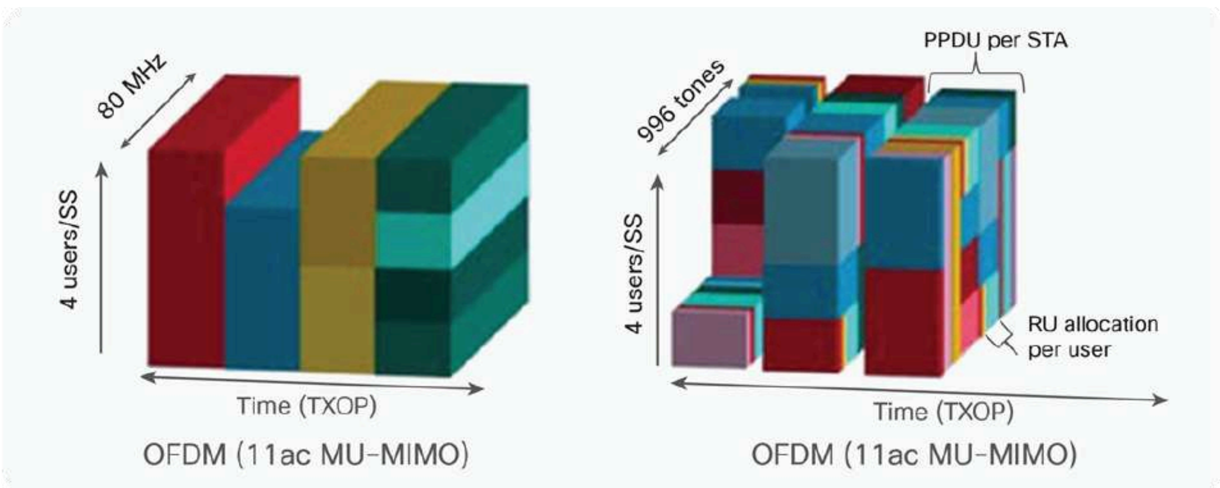


Figure 9 OFDM vs OFDMA

[Editor’s note: In Figure 9, the text on the right should be “OFDMA (11ax MU-MIMO)”]

1.2 Downlink and uplink multi-user MIMO

The downlink version extends an existing 802.11ac feature where an access point determines that multipath conditions allow it to send, in a single time-interval, frames to different client devices. 802.11ax increases the size of downlink MU-MIMO groups, allowing more efficient operation. Uplink multi-user MIMO is a new addition to 802.11ax, but it is deferred to wave 2: like uplink OFDMA, the access point must coordinate the simultaneous transmissions of multiple clients.

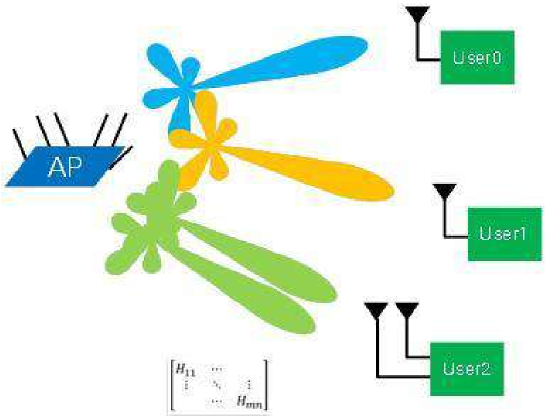


Figure 10 AP using MU-MIMO beamforming to serve multiple users located in spatially diverse positions

1.3 Transmit beamforming

This is another existing feature where an access point uses a number of transmit antennas to land a local maximum signal on a receiver’s antennas. It improves data-rates and extends range.

1.4 Higher order modulation

802.11a/g introduced 64-QAM, and 802.11ac 256-QAM: in 802.11ax, the highest-order modulation is extended to 1024-QAM. This increases peak data-rates under good conditions (high SNR). OFDM symbols, subcarrier spacing and FFT size are all changed to allow efficient operation of small OFDMA subchannels: these changes allow an increase in the length of guard interval without loss of symbol efficiency.

[Editor’s note: Table 3 should be reviewed to add columns for 160 MHz.]

Table 3 802.11ax selected rates (Mbps, short GI)

MCS	Modulation & Rate	20 MHz 1x SS	20 MHz 2x SS	20 MHz 4x SS	20 MHz 8x SS	40 MHz 1x SS	40 MHz 2x SS	40 MHz 4x SS	40 MHz 8x SS	80 MHz 1x SS	80 MHz 2x SS	80 MHz 4x SS	80 MHz 8x SS
0	BPSK 1/2	8.6	17.2	34.4	68.8	17.2	34.4	68.8	137.6	36.0	72.1	144.1	288.2
1	QPSK 1/2	17.2	34.4	68.8	137.6	34.4	68.8	137.6	275.3	72.1	144.1	288.2	576.5
2	QPSK 3/4	25.8	51.6	103.2	206.5	51.6	103.2	206.5	412.9	108.1	216.2	432.4	864.7
3	16-QAM 1/2	34.4	68.8	137.6	275.3	68.8	137.6	275.3	550.6	144.1	288.2	576.5	1,152.9
4	16-QAM 3/4	51.6	103.2	206.5	412.9	103.2	206.5	412.9	825.9	216.2	432.4	864.7	1,729.4
5	64-QAM 1/2	68.8	137.6	275.3	550.6	137.6	275.3	550.6	1,101.2	288.2	576.5	1,152.9	2,305.9
6	64-QAM 3/4	77.4	154.9	309.7	619.4	154.9	309.7	619.4	1,238.8	324.3	648.5	1,297.1	2,594.1
7	64 QAM 5/6	86.0	172.1	344.1	688.2	172.1	344.1	688.2	1,376.5	360.3	720.6	1,441.2	2,882.4
8	256-QAM 3/4	103.2	206.5	412.9	825.9	206.5	412.9	825.9	1,651.8	432.4	864.7	1,729.4	3,458.8
9	256-QAM 5/6	114.7	229.4	458.8	917.6	229.4	458.8	917.6	1,835.3	480.4	960.8	1,921.6	3,843.1
10	1024-QAM 3/4	129.0	258.1	516.2	1,032.4	258.1	516.2	1,032.4	2,064.7	540.4	1,080.9	2,161.8	4,323.5
11	1024-QAM 5/6	143.4	286.8	573.5	1,147.1	286.8	573.5	1,147.1	2,294.1	600.5	1,201.0	2,402.0	4,803.9

1.5 Outdoor operation

A number of features improve outdoor performance. The most important is a new packet format where the most sensitive field is now repeated for robustness. Other features that contribute to better outdoor operation include longer guard intervals and modes that introduce redundancy to allow for error recovery.

1.6 Reduced power consumption

Existing power-save modes are supplemented with new mechanisms allowing longer sleep intervals and scheduled wake times. An 802.11ax AP can negotiate with the participating STAs the use of the Target Wake Time (TWT) function to define a specific time or set of times for individual stations to access the medium. The STAs and the AP exchange information that includes an expected activity duration. This way the AP controls the level of contention and overlap among STAs needing access to the medium. 802.11ax STAs may use TWT to reduce energy consumption, entering a sleep state until their TWT arrives. Furthermore, an AP can additionally devise schedules and deliver TWT values to STAs without individual TWT agreements between them.

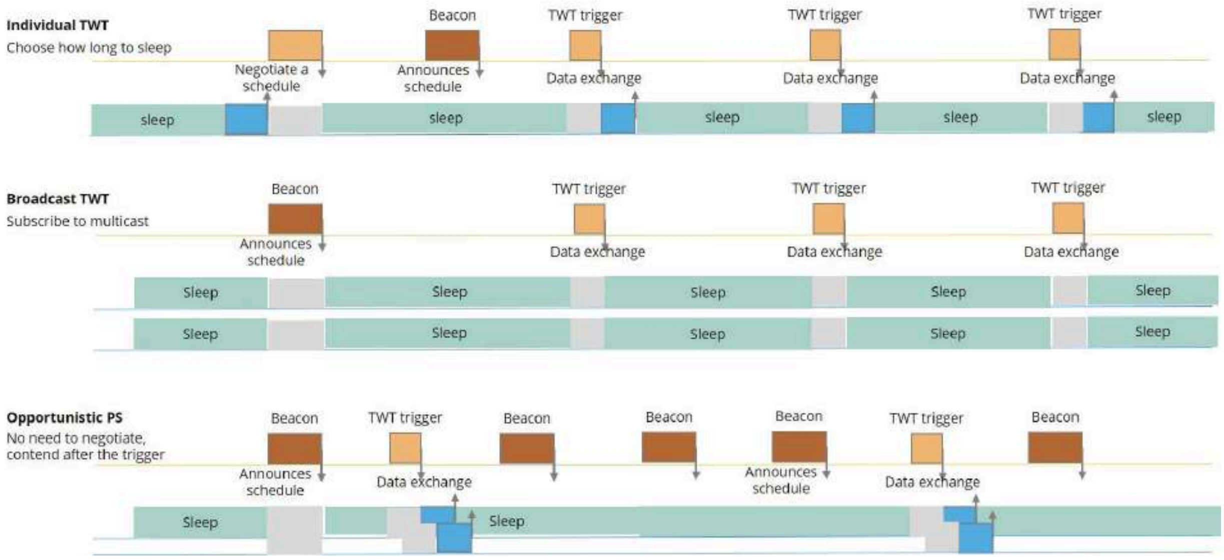


Figure 11 TWT power-save options in 802.11ax

Also, for IoT devices, a 20MHz-channel-only mode is introduced, allowing for simpler, less powerful chips that support only that mode.

1.7 Spatial re-use with color codes

To improve the system level performance and the efficient use of spectrum resources in dense deployment scenarios, the 802.11ax standard implements a spatial reuse technique. STAs can identify signals from overlapping Basic Service Sets (BSS) and make decisions on medium contention and interference management based on this information.

When an STA that is actively listening to the medium detects an 802.11ax frame, it checks the BSS color bit or MAC address in the MAC header. If the BSS color in the detected PPDU is the same color as the one that its associated AP has already announced, then the STA considers that frame as an intra-BSS frame.

However, if the detected frame has a different BSS color than its own, then the STA considers that frame as an inter-BSS frame from an overlapping BSS. The STA then treats the medium as BUSY only during the time it takes the STA to validate that the frame is from an inter-BSS, but not longer than the time indicated as the length of the frame's payload.

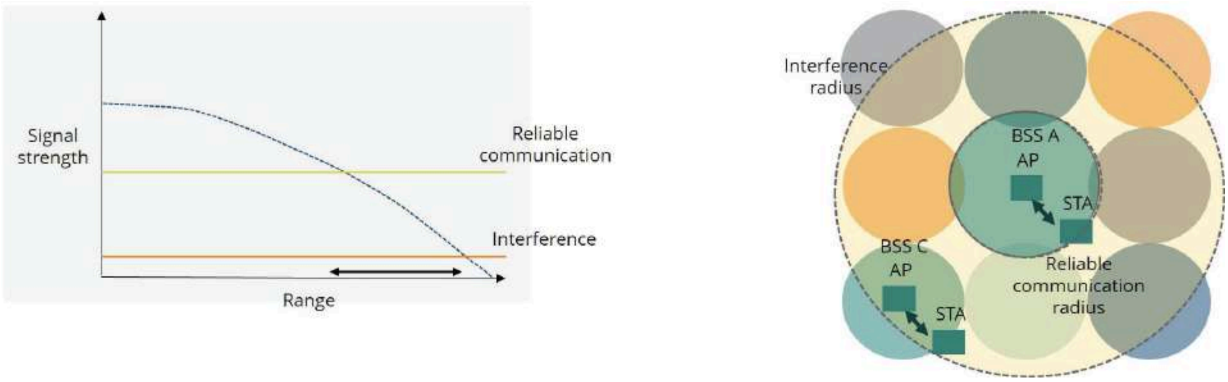


Figure 12 BSS coloring: co-channel interference

BSS coloring works by distinguishing between "same BSS" and "distant BSS" transmissions and applying different CSMA/CA power thresholds. This allows simultaneous transmissions in the different cells, as, in addition to two power thresholds, each client device keeps two network allocation vectors (NAV's) which tell it how long the medium will be occupied.

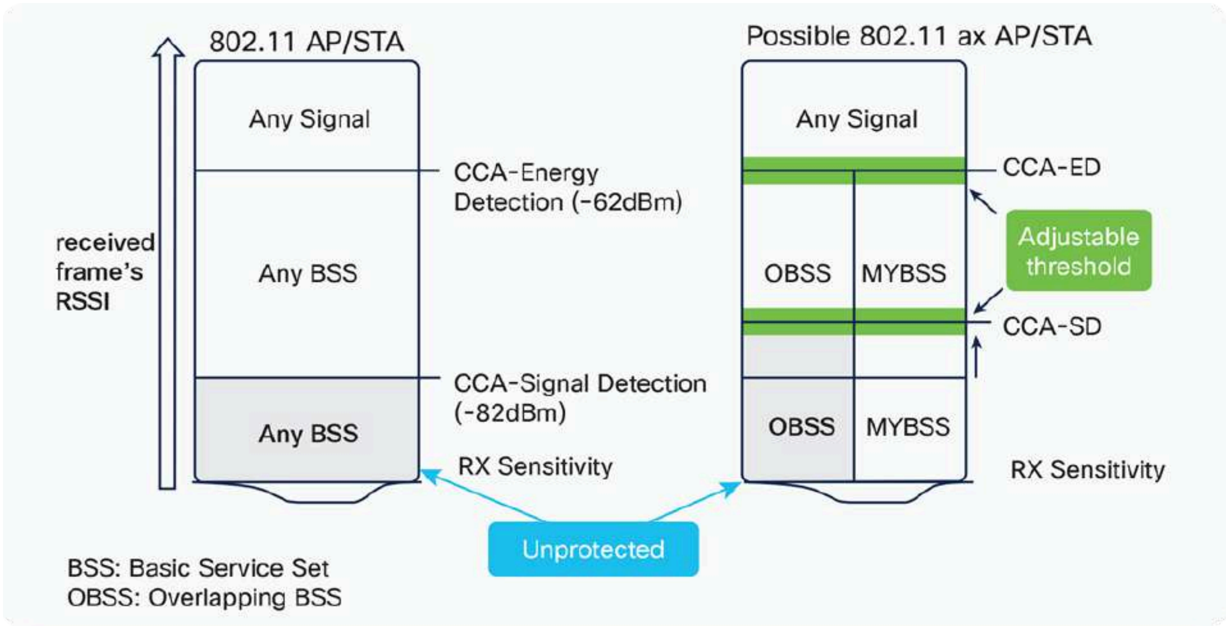


Figure 13 OBSS and BSS Color operation

2. IEEE 802.11be [(Wi-Fi 7)]

IEEE 802.11be, dubbed Extremely High Throughput (EHT), is the next amendment of the IEEE 802.11 standard, which will be designated Wi-Fi 7. Wi-Fi 7 features will expand upon the innovation of Wi-Fi 6 and Wi-Fi 6E, focusing on WLAN indoor and outdoor operation with stationary and pedestrian speeds in the 2.4, 5, and 6 GHz frequency bands.

Development of the 802.11be amendment is ongoing, with an initial draft in March 2021, and a final version expected by early 2024.

2.1 320 MHz Channels & 4K QAM

Wi-Fi 7 enables significantly faster speeds by packing more data into each transmission. 320 MHz channels are twice the size of previous Wi-Fi generations. 4K QAM (Quadrature Amplitude Modulation) enables each signal to more densely embed greater amounts of data compared to the 1K QAM with Wi-Fi 6/6E.
The benefit for a typical Wi-Fi 7 laptop is a potential maximum data rate of almost 5.8 Gbps. This is 2.4X faster than the 2.4 Gbps possible with Wi-Fi 6/6E and could easily enable high quality 8K video streaming or reduce a massive 15 GB file download to roughly 25 seconds vs. the one minute it would take with the best legacy Wi-Fi technology.

2.2 Multi-Link Operation & Deterministic Latency

While legacy Wi-Fi provides access to multiple wireless bands, devices typically choose only one band to make transmissions—switching to another if conditions change. With MLO (Multi-Link Operation), Wi-Fi 7 devices can simultaneously connect on multiple bands. This enables faster speeds through aggregation. Or multiple bands can be used concurrently to share redundant/unique data for improved reliability with ultra-low and precise latencies.

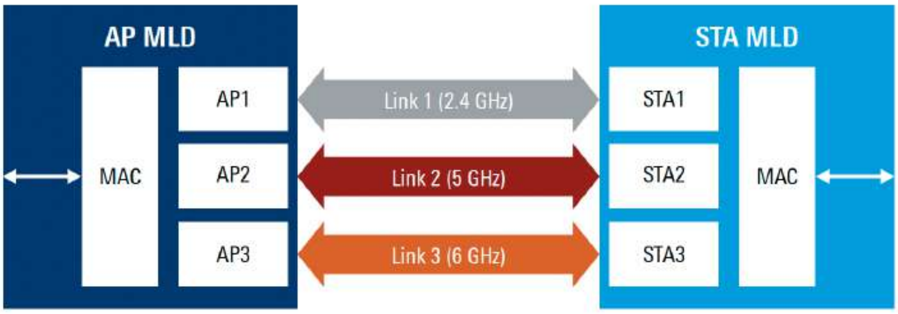


Figure 14 Restricted target wake time principle

2.3 Multi Resource Units (RU) and Puncturing

Multi-RU Puncturing improves the usage of transmission channels by increasing throughput and reducing latency when multiple users are present. It enables the use of multiple resource units, while puncturing is available to avoid interference with incumbent services, the congestion caused by interference and to maintain high transmission speeds.

Puncturing can take 80 MHz and 160 MHZ Wi-Fi channels and slice or bond them in increments of 20 MHz. To help avoid the congestion caused by interference, and it can maintain transmission speeds in multi-user scenarios without dropping the signal.

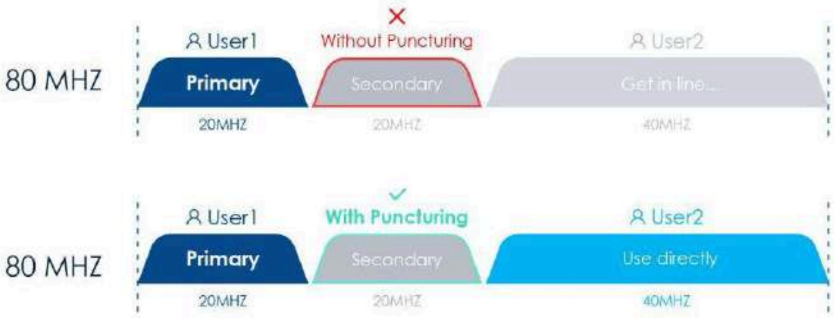


Figure 15 Puncturing improves spectrum effiiciency

[Editor's Note: One proposal to delete sub-section below. Another input to consider including this as Wi-Fi 8 feature.]

[

2.4 Multi-AP Operation

Wi-Fi 7 will have a coordinated transmission between multiple APs. It might also be worthwhile to coordinate beamforming between adjacent APs by forming spatial radiation nulls (null beams) to non-associated STAs in the neighborhood, which allows simultaneous transmission at the same frequency resource. The probably most complex feature under discussion is the joined transmission (c) where multiple APs transmit/receive to/from one or multiple stations using the same frequency in a distributed MIMO scheme.

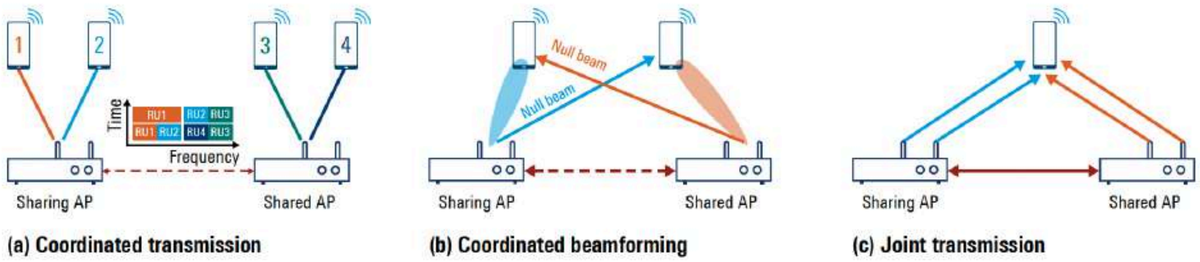


Figure 16 Multi-AP coordination feature principles

]

[Editor’s note: Consider if this information belongs in Section 5.1.2 or Section 7]

Annex 2 : 5GHz (802.11a/h/ /n/ac/ax)

5GHz (802.11a/h/ n/ac/ax)

5 GHz (802.11a/h/ n/ac/ax

Channel	Center Freq	Frequency Range	10	20	40	80	160 MHz	Australia	Japan	India	Singapore	China	Korea	NewZealand	Vietnam	Indonesia
	(MHz)	(MHz)	MHz													
7	5035	5030–5040	10					No	No	No	No	No	No	No	No	No
8	5040	5030–5050		20												
9	5045	5040–5050	10													
11	5055	5050–5060	10													
12	5060	5050–5070		20												
16	5080	5070–5090		20												
32	5160	5150–5170		20				Indoors	Indoors	Yes	Yes	Indoors	Indoors	Indoors	Indoors	Indoors
34	5170	5150–5190			40											
36	5180	5170–5190		20												
38	5190	5170–5210			40											
40	5200	5190–5210		20												
42	5210	5170–5250				80										
44	5220	5210–5230		20												
46	5230	5210–5250			40											
48	5240	5230–5250		20												
50	5250	5170–5330					160	Indoors/DFS/TPC							No	
52	5260	5250–5270		20				Indoors								
54	5270	5250–5290			40											
56	5280	5270–5290		20												
58	5290	5250–5330				80										
60	5300	5290–5310		20												

62	5310	5290–5330			40											
64	5320	5310–5330		20												
68	5340	5330–5350		20				Unknown								
96	5480	5470–5490		20				DFS/TPC				No	DFS/TPC			No
100	5500	5490–5510		20				Yes								
102	5510	5490–5530			40											
104	5520	5510–5530		20												
106	5530	5490–5570				80										
108	5540	5530–5550		20												
110	5550	5530–5570			40											
112	5560	5550–5570		20												
114	5570	5490–5650					160	No								
116	5580	5570–5590		20												
118	5590	5570–5610			40			No								
120	5600	5590–5610		20												
122	5610	5570–5650				80										
124	5620	5610–5630		20												
126	5630	5610–5650			40											
128	5640	5630–5650		20												
132	5660	5650–5670		20				DFC/TPC								
134	5670	5650–5690			40											
136	5680	5670–5690		20												
138	5690	5650–5730				80		No								
140	5700	5690–5710		20				Indoors								
142	5710	5690–5730			40			No								
144	5720	5710–5730		20												
149	5745	5735–5755		20				Yes		Yes	Indoors	Yes	Yes			
151	5755	5735–5775			40											
153	5765	5755–5775		20												

155	5775	5735–5815				80										
157	5785	5775–5795		20												
159	5795	5775–5815			40											
161	5805	5795–5815		20												
163	5815	5735–5895					160	No	No	No	No	No	No			
165	5825	5815–5835		20				Yes		Yes	Indoors	Yes	Yes			
167	5835	5815–5855			40			No	No	No	No	No	No			
169	5845	5835–5855		20												
171	5855	5815–5895				80										
173	5865	5855–5875		20												
175	5875	5855–5895			40			No								
177	5885	5875–5895		20												
180	5900	5895–5905	10													
182	5910	5905–5915	10					No			No	No	No	No	No	No
183	5915	5905–5925		20												
Channel	**Center Freq**	**Frequency Range**	**10**	**20**	**40**	**80**	**160**	**Australia**	**Japan**	**India**	**Singapore**	**China**	**Korea**	**New Zealand**	**Vietnam**	**Indonesia**
	(MHz)	**(MHz)**														

Annex 3: Questionnaire Responses

Questionnaire

Question 1: What is/are current frequency ranges for license-exempt (in some countries also known as general use license, class license) WAS/RLAN technology to use in your country?

Answer:

	Frequency range	Maximum EIRP	Maximum PSD	Use condition (s)	Applicable Technical Standard (s)
Bhutan					
Nepal	865 – 868 MHz			Non-Exclusive and Non-protective shared basis Cannot be used for Backhaul/Backbone Network	Machine to Machine(M2M)/Internet of Things
	2.4 – 2.4835 GHz	4W (36 dBm)		No exclusive right, shall be used in non-protection and shared basis. Cannot be used for Backhaul/Backbone Network	
	5.150 – 5.350 GHz	4W (36 dBm)		Non-Exclusive and Non-protective shared basis Cannot be used for Backhaul/Backbone Network	
	5.470 – 5.65 GHz	4W (36 dBm)		Non-Exclusive and Non-protective shared basis Cannot be used for Backhaul/Backbone Network	
	5.725 – 5.825 GHz	4W (36 dBm)		No exclusive right, shall be used in non-protection and shared basis. Cannot be used for Backhaul/Backbone Network	
	6 – 8.5 GHz	0 dBm in 50 MHz	-41.3 dBm / MHz	Non-Exclusive and Non-protective shared basis without interfering telecommunication services Cannot be used for Backhaul/Backbone Network	
Thailand	2400-2500 MHz	100 mW		Indoor/outdoor	EN 300 328 FCC Part 15.247
	5150-5350 MHz	200 mW		Indoor DFS and TPC are required in 5250-5350 MHz	EN 301 893 FCC Part 15.407
	5470-5725 MHz	1W		Indoor/outdoor DFS and TPC are required in 5470-5725 MHz	EN 301 893 FCC Part 15.407
	5725-5850 MHz	1W		Indoor/outdoor	EN 302 502 FCC Part 15.247 FCC Part 15.407

	5925-6425 MHz	25 mW	1.25 mW/MHz	Indoor/outdoor	FCC Part 15.407
		250 mW	12.5 mW/MHz	Indoor	
Japan	2400-2483 .5 MHz	-	FHSS (within 2427-2470.75 MHz band): 3mW/MHz SS: 10mW/MHz OFDM (26MHz): 10mW/MHz OFDM (40MHz): 5mW/MHz Others: 10mW	Indoor/outdoor	Article 49-20, Paragraph 1 of the Radio Equipment Regulations
	2471-2497 MHz	-	10mW/MHz	Indoor/outdoor	Article 49-20, Paragraph 2 of the Radio Equipment Regulations
	5 150-5 250 MHz	-	Indoor/outdoor: 20 MHz: 10 mW/MHz 40 MHz: 5 mW/MHz 80 MHz: 2.5 mW/MHz 160 MHz: 1.25 mW/MHz Indoor/outdoor: With EIRP mask for elevation above the horizon: 20 MHz: 50 mW/MHz 40 MHz: 25 mW/MHz 80 MHz: 12.5 mW/MHz Inside automobiles: 20MHz: 2 mW/MHz 40MHz: 1 mW/MHz 80MHz: 0.5 mW/MHz	Indoor/outdoor or inside automobiles Registration is required for access points for outdoor use or with a maximum EIRP greater than 200mW	Article 49-20, Paragraph 3 of the Radio Equipment Regulations
	5 250-5 350 MHz	-	20 MHz: 10 mW/MHz 40 MHz: 5 mW/MHz 80 MHz: 2.5 mW/MHz 160 MHz: 1.25 mW/MHz	DFS required, indoor only, TPC or reduced transmission power by 3 dB	Article 49-20, Paragraph 3 of the Radio Equipment Regulations
	5 470-5 730 MHz	-	20 MHz: 50 mW/MHz 40 MHz: 25 mW/MHz 80 MHz: 12.5 mW/MHz 160 MHz: 6.25 mW/MHz	DFS required, not allowed in the sky, TPC or reduced transmission power by 3 dB	Article 49-20, Paragraph 3 of the Radio Equipment Regulations
	5 925-6 425 MHz	25 mW (VLP), 200 mW (LPI)	VLP: 20 MHz: 1.25 mW/MHz 40 MHz: 0.625 mW/MHz 80 MHz: 0.3125 mW/MHz 160 MHz: 0.15625 mW/MHz 320 MHz: 0.078125 mW/MHz LPI: 20 MHz: 10 mW/MHz 40 MHz: 5 mW/MHz 80 MHz: 2.5 mW/MHz 160 MHz: 1.25 mW/MHz 320 MHz: 0.625 mW/MHz	Indoor only for LPI	Article 49-20, Paragraph 4 of the Radio Equipment Regulations

Malaysia	2400 MHz to 2500 MHz	500 mW	-	-	i. Class Assignment for Short-range Radiocommunication Device ii. Technical Code for the Specification for Short Range Devices – Specifications Note: The use of frequency band(s) for devices that have been listed in the Class Assignment are subject to the requirements and conditions as specified in the Class Assignment. The latest Class Assignment document can be found in this URL: http://www.mcmc.gov.my/en/spectrum/assignment-of-spectrum/class-assignment.
	5150 MHz to 5250 MHz	200 mW	-	Outdoor use only	
		1 W		Indoor use only	
	5250 MHz to 5350 MHz	1 W	10 mW/MHz	•Indoor use only •The devices shall use Dynamic Frequency Selection (DFS) and Transmitter Power Control (TPC)	
	5470 MHz to 5650 MHz	1 W	10 mW/MHz	The devices shall use Dynamic Frequency Selection (DFS) and Transmitter Power Control (TPC)	
	5725 MHz to 5875 MHz	1 W	-	-	
	5925 MHz to 6425 MHz	25 mW	1.25 mW/MHz (10 mW/MHz for narrowband usages)	Indoor and outdoor use	
		200 mW	10 mW/MHz	Indoor use only	
Australia	2400–2483.5 MHz	500 mW		Either: (a) the transmitter must meet the requirements of ETSI EN 300 328; or (b) a minimum of 15 hopping frequencies must be used.	
	2400–2483.5 MHz	4 W		A minimum of 75 hopping frequencies must be used.	
	5150–5250 MHz	1W maximum EIRP		(a) The transmitter is allowed indoor and outdoor (b) Maximum EIRP at any elevation angle above 30 degrees as measured from the horizon must not exceed 125 mW (21 dBm)	

		200 mW (averaged over the entire transmission burst)	10mW/MHz or 40µW/4kHz for narrowband use	(a) The transmitter must only be used indoors. (b) The power spectral density of a transmitter with a bandwidth greater than or equal to 1 MHz must not exceed 10 mW EIRP per MHz. (c) The power spectral density of a transmitter with a bandwidth less than 1 MHz must not exceed 40 µW EIRP per 4 kHz.	
	5250–5350 MHz	200 mW (averaged over the entire transmission burst)	10mW/MHz or 40µW/4kHz for narrowband use	(a) The transmitter must only be used indoors. (b) The power spectral density of a transmitter with a bandwidth greater than or equal to 1 MHz must not exceed 10 mW EIRP per MHz. (c) The power spectral density of a transmitter with a bandwidth less than 1 MHz must not exceed 40 µW EIRP per 4 kHz. (d) The transmitter must use Dynamic Frequency Selection (DFS). (e) If the maximum EIRP is greater than 100 mW, the transmitter must use Transmit Power Control (TPC).	

	(a) 5470–5600 (b) 5650–5725	1 W (averaged over the entire transmission burst)	50mW/MHz	(a) The maximum radiated mean power density must not exceed 50 mW/MHz EIRP in any 1 MHz band. (b) The transmitter must use Dynamic Frequency Selection (DFS). (c) If the maximum EIRP is greater than 500 mW, the transmitter must use Transmit Power Control (TPC).	
	5925-6425 MHz	250 mW	12.5mW/MHz	(a) The transmitter must only be used indoors. (b) The power spectral density of the transmitter must not exceed 12.5 mW EIRP per MHz. (c) Contention-based protocols for multiple access, such as Carrier Sense Multiple Access (CSMA) or Multiple Access Collision Avoidance (MACA), must be implemented.	
	5925-6425 MHz	25 mW	1.25mW/MHz	(a) The power spectral density of the transmitter must not exceed 1.25 mW EIRP per MHz. (b) Contention-based protocols for multiple access, such as Carrier Sense Multiple Access (CSMA) or Multiple Access Collision Avoidance (MACA), must be implemented.	

Indoneda	2400 - 2483.5 MHz	Indoor: 27 dBm Outdoor: 36 dBm	-	Indoor (maximum bandwidth 40 MHz) Outdoor (maximum bandwidth 20 MHz) (access/backhaul)	[Director General SDPPI Regulation No.2 of 2019]()
	5150 - 5250 MHz	23 dBm	-	Indoor (maximum bandwidth 80 MHz) (access)	[Director General SDPPI Regulation No.2 of 2019]()
	5250 - 5350 MHz	23 dBm	-	Indoor (maximum bandwidth 80 MHz) (access)	[Director General SDPPI Regulation No.2 of 2019]()
	5150 - 5350 MHz	23 dBm	-	Indoor (maximum bandwidth 160 MHz) (access)	The technical standard is still being developed
	5725 - 5825 MHz	Indoor: 23 dBm Outdoor: 36 dBm	-	Indoor (maximum bandwidth 80 MHz) Outdoor (maximum bandwidth 20 MHz) (access/backhaul)	[Director General SDPPI Regulation No.2 of 2019]()
	57 - 64 GHz	40 dBm	-	Indoor (maximum bandwidth 2.16 GHz) (access)	The technical standard for RLAN 60 GHz is still being developed
India	2400-2483.5 MHz[22]	36 dBm		Non-interference, non-protection and shared (non-exclusive) basis.	

[22] https://dot.gov.in/spectrummanagement/delicensing-24-24835-ghz-band-gsr-45-e-5150-5350-ghz-gsr-46-e-and-5725-5875-ghz

	5.150-5.250 GHz[23]	36 dBm 21 dBm 53 dBm 30 dBm	17 dBm/MHz 11 dBm/MHz	Access point: ≤ 6 dBi antenna gain & 30 dBm conducted power. Above 30°elevation (outdoor) Fixed point to point access point: ≤ 23 dBi antenna gain & 30 dBm conducted power. Client/portable mobile device: ≤ 6 dBi antenna gain & 250 mW conducted power	
	5.250-5.350 GHz 5.470-5.725 GHz	30 dBm	11 dBm/MHz	Access point: ≤ 6 dBi antenna gain & 250 mW conducted power or 11dBm + 10 log B, whichever is less, where 'B' is the emission bandwidth in MHz.	
	5.725-5.875 GHz	36 dBm 53 dBm	30 dBm/500 kHz	Access point: ≤ 6 dBi antenna gain & 30 dBm conducted power. Fixed point to point access point: ≤ 23 dBi antenna gain & 30 dBm conducted power.	
Vietnam	2400 ÷ 2483,5 MHz	≤ 200 mW EIRP (for equipment using FHSS modulation)		Common use condition (for all RLAN bands): Organizations and individuals deploy and use WLAN/RLAN equipment that need to comply with laws and regulations on telecommunications, information security and data protection.	QCVN 54:2020/BTTTT
		≤ 10 mW/1 MHz EIRP (for equipment using non-FHSS modulation)			
	5150 ÷ 5250 MHz	≤ 200 mW EIRP		Using in an indoor environment (Indoor use) or an environment with electromagnetic wave shielding (ie: in car)	QCVN 65:2013/BTTTT

[23] https://dot.gov.in/spectrummanagement/license-exemption-5-ghz-gsr-1048e-dated-22102018

	5250 ÷ 5350 MHz	≤ 200 mW EIRP (for equipment being adjustable power)		The device must be capable of dynamic frequency selection (DFS)	QCVN 65:2013/BTTTT
		≤ 100 mW EIRP (for equipment being non-adjustable power)		The device must be capable of dynamic frequency selection (DFS)	
	5470 ÷ 5725 MHz	≤ 1 W EIRP (for equipment being adjustable power)		The device must be capable of dynamic frequency selection (DFS)	QCVN 65:2013/BTTTT
		≤ 500 mW EIRP (for equipment being non-adjustable power)		The device must be capable of dynamic frequency selection (DFS)	
	5725 ÷ 5850 MHz	≤ 1 W EIRP			QCVN 65:2013/BTTTT
	57 ÷ 66 GHz	≤ 10 W EIRP		- Require to use the integrated antenna - Do not install in a fixed outdoor location	QCVN 88:2015/BTTTT
China	2 400-2 483.5	20 dBm (e.i.r.p. for integrated antenna gain < 10 dBi) 27 dBm (e.i.r.p. for antenna gain >= 10 dBi)	10 dBm/MHz (e.i.r.p. for Integrated antenna gain < 10 dBi) 17 dBm/MHz (e.i.r.p. for Integrated antenna gain >= 10 dBi) Frequency hopping <= 20dBm/100kHz	Interference Avoidance mechanism is mandatory Additional out of band emission limit applies in order to protect the service in the adjacent band and in specific bands. *	National regulation rules applied
	5 150-5 350	23 dBm (e.i.r.p.)	10 dBm/MHz (e.i.r.p.)	Indoor use only (use within vehicle is prohibited). 5 250-5 350 MHz, TPC and DFS are mandatory. Interference Avoidance mechanism is mandatory Additional out of band emission limit applies in order to protect the service in the adjacent band and in specific bands*	National regulation rules applied

	5 725-5 850	33 dBm (e.i.r.p.)	19 dBm/MHz (e.i.r.p)	Interference Avoidance mechanism is mandatory Additional out of band emission limit applies in order to protect the service in the adjacent band and in specific bands*	National regulation rules applied
Korea	5 150 – 5 350 MHz	30 dBm	10 dBm	PSD should be reduced depending on the occupied bandwidth. Especially, PSD should be reduced to lower than 3.97 dBm/MHz for any channel which includes all or some of 5 230 - 5 250 MHz (and see domestic regulation for detail). TPC and DFS requirements should be complied in 5 250 - 5 350 MHz band.	
	5 470 – 5 850 MHz	30 dBm	10 dBm/MHz	PSD should be reduced depending on the occupied bandwidth. TPC and DFS requirements should be complied in 5 470 - 5 725 MHz band.	
	5 925 ~ 7 125 MHz	24 dBm	2 dBm/MHz	LPI[1)] (Indoor only) (LBT is required) 1) - allowed only the devices installed and operated by being connected to the power supply within a building or the devices that communicate with these devices - not allowed in moving objects, such as vehicles, aircraft, railways, ship, drones, etc. - applicable for only indoor usage.	Unlicensed Wireless Equipment Regulation Article No.7
	5 925 ~ 6 425 MHz	14 dBm	1 dBm/MHz	VLP[2)] (Indoor/Outdoor) (LBT is required) 2) - not allowed in a drone - devices built in vehicle are allowed in 6 085-6 425 MHz band only - applicable for both indoor and outdoor usage	

		24 dBm	2 dBm/MHz	Subway[3)] (Inside subway train only) (LBT is required) 3) - allowed only the devices installed and operated by being connected to the power supply within a subway train or the devices that communicate with these devices	
Sri Lanka		Please refer the Annexure A Table 6 of Radio and Telecommunications Terminal Equipment (RTTE) Type Approval Rules given in the following link (Page no 28A): https://trc.gov.lk/images/SM/RTTE_GAZETTE-English.pdf			
Brunei	2.4000 – 2.4835 GHz	<= 200 mW (e.i.r.p.)		Operating under this provision shall be allowed to transmit between 100 mW and 200mW (e.i.r.p), and approved on exceptional basis	FCC Part 15 § 15.247 or EN300 328 FCC Part 15 § 15.209; or EN 300 328
	5.150 – 5.350 GHz	<= 1000 mW (e.i.r.p.)		WLAN operating in 5.250 – 5.350 GHz under this provision shall employ Dynamic Frequency Selection (DFS) mechanism and implement Transmit Power Control (TPC). Non-localised operations shall be approved on an exceptional basis	FCC Part 15 § 15.407 (b) or EN 301 893 FCC Part 15 § 15.407 or EN 301 893
	5.470 – 5.725 GHz	<= 1000 mW (e.i.r.p.)		WLAN operating under his provision shall employ Dynamic Frequency Selection (DFS) mechanism and implement Transmit Power Control (TPC). Non-localised operations shall be approved on an exceptional basis	
	5.725 – 5.850 GHz	<= 4000 mW (e.i.r.p.)		Operating under this provision shall be allowed to transmit between 100 mW and 200mW (e.i.r.p), and approved on exceptional basis	FCC Part 15 § 15.209 FCC Part 15 § 15.247 or
	5.725 – 5.850 GHz	<= 100 mW (e.i.r.p.)			
Pakistan	2.4 – 2.5 GHz	30 dBm			
	5.15 – 5.25 GHz	200 mW		Indoors	
	5.25 – 5.35 GHz	200 mW		Indoors / DFS / TPC	

	5.47 – 5.725 GHz	200 mW		Indoors / DFS / TPC Indoor / outdoor *(Depending upon channel)*	
	5.725 – 5.875 GHz	1W for indoor and outdoor use with up to maximum antenna gain of 23 dBi (max EIRP = 30 dBm + 23 dBi)		Indoor / outdoor	
	57 – 66 GHz	+ 40 dBm		Indoor / outdoor	
Palau	2.4 – 2.4835 GHz	1 Watt		FCC,CE,MIC & ACMA Certifications Standard (s)	FCC,CE,MIC & ACMA Certifications Standard (s)
	5.15 – 5.85 GH	1 Watt		FCC,CE,MIC & ACMA Certifications Standard (s)	FCC,CE,MIC & ACMA Certifications Standard (s)
Nepal	2.4 – 2.4835 GHz	4W (36 dBm)			
New Zealand	2400 - 2483,5 MHz	See: General User Radio Licence for Short Range Devices https://www.rsm.govt.nz/about/publications/gazette-notices/general-user-radio-licence-gurl-notices/			See: Radiocommunications (Radio Standards) Notice https://www.rsm.govt.nz/about/publications/gazette-notices/product-compliance-gazette-notices/
	5150 – 5350 MHz				
	5470 – 5875 MHz				
	5925 – 6425 MHz				

Please provide detailed information such as indoor/outdoor, DFS requirement in the "use condition" field.

Question 2: Is there any WAS/RLAN devices certification and labelling rules in your country and if so, what are these rules?

Answer:

Bhutan	Type Approval Rules and Regulations. However, we do not require WLAN with low power devices to be Type Approved.
Nepal	Yes. WAS/RLAN devices shall be type approved by Nepal Telecommunications Authority. Only type approved equipment are allowed to be imported in Nepal. However, Type Approval Certificate is not an import license. There is WAS/RLAN devices certification and labelling rules. NTA determines and/or approves the

	standard and quality standard for plant and equipment relating to telecommunications services based on Spectrum Policy. For detail refer Type approval working procedure for customer premises radio Telecommunications Equipment-2016 (TAP-04).
Thailand	A Supplier's Declaration of Conformity (SDoC) rule applies.
Japan	Yes, there are technical standards certification and labelling rules for WAS/RLAN equipment as follows: - Ordinance on Technical Standards Conformity Certification of Specified Radio Equipment (Ordinance of the Ministry of Posts and Telecommunications No. 37 of 1981); - Notice to define technical requirements for radio equipment of radio stations for low-power data communication systems (MIC Notice No. 48 of 2007, No.291 of 2022).
Malaysia	All communication devices (including WAS/RLAN devices) which are required to be certified shall be certified pursuant to Regulation 14 of the Communications and Multimedia (Technical Standards) Regulations 2000. Certified communication devices shall bear MCMC label to indicate that they comply with the standards and legal requirements enforced by MCMC. For details, please refer to: http://www.mcmc.gov.my/en/communications-equipment/certification-of-communications-equipment.
Australia	Yes, Australian labeling rules apply to most radiocommunications transmitters. All short range devices in Australia must be labelled to certify that they conform to applicable standard – the Radiocommunications (Short Range Devices) Standard 2014, which references AS/NZS 4268 (which, in turn, makes reference to other international standard for various device types).
Indonesia	All WAS/RLAN devices must be certified and labeled in accordance with the Regulation of the Minister of Communications and Informatics No. 16 of 2018. The testing parameters for certification shall refer to Director General of Resources Management and Equipment of Posts and Informatics (DG SDPPI) Regulation No.2 of 2019.
India	Yes, Equipment Type Approval. The procedure along with application for obtaining Equipment Type Approval is included in the relevant notification. https://dot.gov.in/spectrummanagement/license-exemption-5-ghz-gsr-1048e-dated-22102018
Vietnam	There are some rules to certificate and label for WAS/RLAN device: -Firstly, EMC measurement is performed in a shielded room. Measurement results will be issued. -Secondly, If the measurement results meet the technical standards the device will get a declaration of conformity, a certification and a label (being specified in the circular No. 02/2022/TT-BTTTT).
China	Devices certification is required. See details at: https://ythzxfw.miit.gov.cn/lawGuide?data=e108714ad0804b5d8e9f2c8c09049875
Korea	Public Notice on Conformity Assessment of Broadcasting and Communication Equipment, etc. Please see the relevant website https://www.rra.go.kr/en/cas/intro.do - In the Public Notice, Chapter 2 (Certification) includes Application for conformity certification (Article 5), Examination of conformity certification (Article 6), and Issuance of certificate of conformity (Article 7). - In the Public Notice above, Article 23 stipulates labelling rules. - Most RF (radio frequency) devices must be approved through the certification of conformity. For devices that may affect the radio environment, broadcast communications network, or the like, as well as devices whose normal operation is subject to possible interference from radio waves, the certificate of conformity can be applied for from the National Radio Research Agency (RRA) with the appropriate documentation.
Sri Lanka	Radio And Telecommunications Terminal Equipment (RTTE) Type Approval Rules 2020. Please refer the following link for more details. https://www.trc.gov.lk/content/files/licensing/RTTE_GAZETTE-English.pdf
Brunei	Yes, Equipment has to be Type Approved and undergo Equipment Registration for compliance and labelling. http://online.aiti.gov.bn/
Pakistan	Yes, as part of type approval technical regulations 2021 which are in vogue within Pakistan, all type approved devices are required to affix a label stating device is "PTA Type Approved". PTA allows both e-labelling and traditional labelling option for ease of manufacturers.
Palau	FCC,CE,MIC & ACMA Certifications Standard (s)
New Zealand	See compliance information for suppliers https://www.rsm.govt.nz/business-individuals/supplier-compliance/steps/step1-meet-standards/

Question 3: What's the current utilization of existing WAS/RLAN spectrum bands by the WAS/RLAN in your country? Do you have any measures of the utilization of existing WAS/RLAN spectrum bands

Answer:

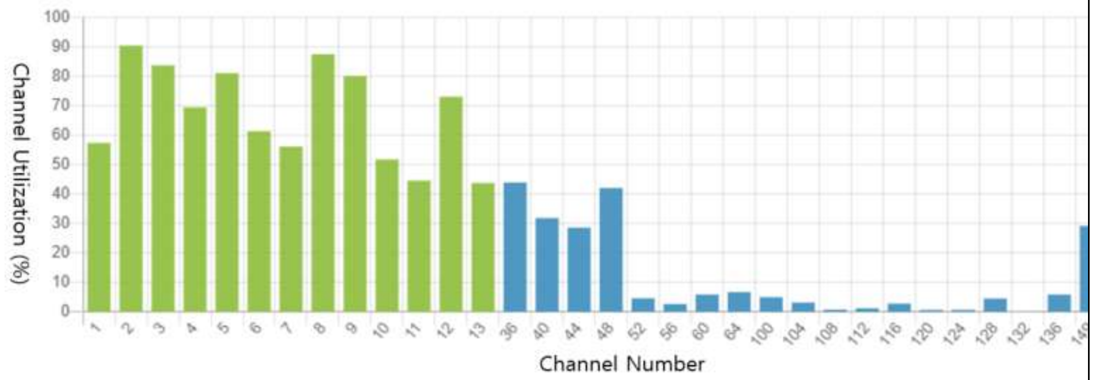
<table>
<tr><td>Bhutan</td><td>ISM Band</td></tr>
<tr><td>Nepal</td><td>2.4GHz and 5.8GHz bands (unlicensed bands) are widely used for Wireless LAN.</td></tr>
<tr><td>Thailand</td><td>WAS/RLAN equipment is license exempted and can be used freely nationwide</td></tr>
<tr><td>Japan</td><td>The utilization of the bands is not measured.</td></tr>
<tr><td>Malaysia</td><td>Such information is not available.</td></tr>
<tr><td>Australia</td><td>Australia does not keep records of utilization of spectrum bands authorized for use by class licences, but utilization can be characterized as extensive. The ACMA does not directly measure utilization of these bands.</td></tr>
<tr><td>Indonesia</td><td>The current WAS/RLAN spectrum bands are utilized for access and backhauling as transport network.
In the future, registration method for measuring the utilization of RLAN that used for outdoor (access/backhaul) will be developed.</td></tr>
<tr><td>India</td><td>The utilization is for indoor and outdoor.</td></tr>
<tr><td>Vietnam</td><td>The designed bands for WAS/RLAN are widely utilized, with various type of application such as public/private Wi-Fi access, wifi direct, bluetooth, Ip camera, remote control.
In case of licence-exempted band, so far there is no report on the utilization of existing WAS/RLAN spectrum bands.</td></tr>
<tr><td>China</td><td></td></tr>
<tr><td>Korea</td><td>The annual data for conformity assessment number of 2.4/5/6 GHz WAS/RLAN

- On average over 12 K devices, unlicensed devices such as WAS/RLAN in 2.4 ㎓, 5 ㎓and 6㎓ band, are newly certified every year in Korea. And over 68 M devices were sold.

<table>
<tr><td rowspan="2">Frequency Band</td><td colspan="4">The number of certified devices</td></tr>
<tr><td>2020</td><td>2021</td><td>2022</td><td>Average</td></tr>
<tr><td>2.4 ㎓ band</td><td>10,800</td><td>11,411</td><td>11,733</td><td>11,314</td></tr>
<tr><td>5 ㎓ band</td><td>1,371</td><td>1,351</td><td>1,487</td><td>1,403</td></tr>
<tr><td>6 ㎓ band</td><td>1</td><td>99</td><td>396</td><td>165</td></tr>
<tr><td>Total</td><td>12,172</td><td>12,861</td><td>13,616</td><td>12,882</td></tr>
</table>
Note : Multifunction devices such as smart phones, tablets, and lap-top PCs were excluded.

<table>
<tr><td rowspan="2">Frequency Band</td><td colspan="4">The number of WAS/RLAN devices sold</td></tr>
<tr><td>2020</td><td>2021</td><td>2022</td><td>Average</td></tr>
<tr><td>2.4 ㎓ band</td><td>69,821,832</td><td>58,102,434</td><td>48,570,108</td><td>58,831,491</td></tr>
<tr><td>5 ㎓ band</td><td>16,600,906</td><td>7,972,220</td><td>4,747,660</td><td>9,773,595</td></tr>
<tr><td>Total</td><td>86,422,738</td><td>66,074,654</td><td>53,317,768</td><td>68,605,086</td></tr>
</table>
Note: Multifunction devices such as smartphones, tablets, and laptop PCs were excluded.
The number of devices sold each year accounts for the sales of devices certified in the last 3 years prior to the sales, meaning 2020 sales indicate the sale of devices certified between 2017 and 2019.

- Below is an example of measurement data for the utilization of WAS/RLAN channel in Seoul.</td></tr>
</table>

	 *Note: This is an example of Gangnam Subway Station between 11 AM and 12 PM on April 22, 2023. The channel utilization of 1, 5, 9, and 13 was over 90% for 3 hours a day on average.* *The channel utilization of 36, 44, and 149 was over 50% for 7 hours a day on average.*
Sri Lanka	No
Brunei	The band are widely used for public on low power device and wireless LAN.
Pakistan	The frequency band 2.4 GHz & 5.7 GHz are heavily utilized for RLAN services in Pakistan from past many years. Recently, the frequency bands 5.150 – 5.725 GHz and 57- 66 GHz bands have also been approved for RLAN.
New Zealand	No, operation is under a General User Radio Licence, which is issued for all of New Zealand and no data is recorded on use.

Question 4: What are the current fixed broadband technologies used in your country (e.g., Cable, Fiber, unlicensed or cellular based FWA, etc.), and what is the adoption rates for fixed broadband services (e.g., xDSL/ FTTx/FWA/satellite) in your country?
Answer:

<table>
<tr><td>Bhutan</td><td>Fixed Broadband Internet, Fixed Wireless Internet</td></tr>
<tr><td>Nepal</td><td>Current fixed broadband technologies used are as follows
• Cable
• Optical Fiber
• Unlicensed FWA
• Cellular based FWA

Adoption rates for fixed broadband services are:
<table>
<tr><td>S. No</td><td>Services</td><td>Market Proportion based on active subscribers</td></tr>
<tr><td>1</td><td>Fixed Broadband (Wired)</td><td>43.68</td></tr>
<tr><td>2</td><td>Fixed Broadband (Wireless)</td><td>0.201</td></tr>
<tr><td>3</td><td>Mobile Broadband</td><td>56.12</td></tr>
</table>
Population penetration for fixed broadband has increased from 35.48% to 43.23% during a period of 1 year (October 2022-October 2023.</td></tr>
<tr><td>Thailand</td><td>xDSL, Cable Modem and FTTx are available</td></tr>
<tr><td>Japan</td><td>The adoption rate for fixed broadband technologies (as of March 31, 2022):
- Fiber: 99.72%
The number of subscribers (as of September 30, 2023):
<Fixed broadband> total 46.48 million
FTTH: 39.97 million
CATV: 6.23 million
DSL: 0.28 million</td></tr>
<tr><td>Malaysia</td><td>The current fixed broadband technologies used in Malaysia includes fibre, copper and other technologies such as satellite, FWA and Gigawire. As of Q4 2022, the fixed broadband subscriptions</td></tr>
</table>

<table>
<tr><td></td><td>in Malaysia stands at 4.22 million, with 47.6% penetration rate per 100 premises. The penetration rates of the fixed broadband services by technology are as follows:
<table><tr><th>Technology</th><th>Penetration Rate per 100 premises (%)</th></tr><tr><td>FTTx</td><td>46.5</td></tr><tr><td>xDSL</td><td>0.8</td></tr><tr><td>FWA</td><td>0.2</td></tr><tr><td>Satellite</td><td>0.1</td></tr><tr><td>Others*</td><td>0.1</td></tr></table>* Includes Ethernet and Gigawire</td></tr>
<tr><td>Australia</td><td>In Australia, 95% of broadband connections are delivered by the government-owned National Broadband Network (NBN Co.) Statistics collected by the competition regulator (ACCC) show that current fixed technologies include Fibre optic cable (Fibre optic includes fibre-to-the-curb (FTTC), fibre-to-the-basement (FTTB), fibre-to-the-node (FTTN) and fibre-to-the-premises (FTTP)), hybrid-fibre coaxial cable (HFC) and Fixed Wireless.

Adoption rates of nbn services in June 2022 were:
> FTTN: 35.5%
> HFC: 23.3%
> FTTP: 20.4%
> FTTC: 12.8%
> FTTB: 3.2%
> FWA: 4.6%.
Fixed wireless is also offered by commercial mobile network operators. Nbn has 400k fixed wireless customers, TPG and Optus reported a further 377,000 fixed wireless customers at December 31, 2022 (source: December quarter 2022 report | ACCC).</td></tr>
<tr><td>Indonesia</td><td>Fixed broadband technologies used in Indonesia mostly based on fiber optic and satellite.
Adoption rate for fixed broadband services (FTTx):
Year 2021 : 17.23 % households
Year 2022 : 22.91 % households
Total household : 68,700,700 (data 2019)</td></tr>
<tr><td>India</td><td></td></tr>
<tr><td>Vietnam</td><td>- CaTV (Internet over cable TV), xDSL, FTTH and cellular based FWA are the current fixed broadband technologies.
- By the end of 2022, FTTx connection has been deployed to 100% of communes/wards/ townships, 91% of villages, 100% of schools, 72.4% of household (20 million houses).</td></tr>
<tr><td>China</td><td>Fixed networks(fiber) have gradually upgrade from 100 Mbit/s to 1000 Mbit/s. By the end of 2022, 15.23 million 10G PON ports with gigabit service capabilities have been built, nearly double the level of 2021. 110 cities across China have reached the gigabit city standard.
By the end of 2022, China had 590 million fixed broadband access users, with a population penetration rate of 41.8 units per 100 people.
https://www.miit.gov.cn/jgsj/yxj/xxfb/art/2023/art_69798e71872c407ab677fd1c73885337.html</td></tr>
<tr><td>Korea</td><td>Fiber and FTTx are used as one of major technologies for fixed broadband.</td></tr>
<tr><td>Sri Lanka</td><td><table><tr><th>Fixed broadband technology</th><th>Adoption rate</th></tr><tr><td>xDSL</td><td>61%</td></tr><tr><td>FWA</td><td>37%</td></tr><tr><td>FTTX</td><td>2%</td></tr></table></td></tr>
<tr><td>Brunei</td><td>As of June 2023, FTTH enrolment with 92% coverage area.</td></tr>
<tr><td>Pakistan</td><td>Cable, Fiber/FTTx, HFC, through Point-to-Point link on 5.725 – 5.875 GHz band with Max. EIRP 30 dBm</td></tr>
<tr><td>Palau</td><td>Cable fiber, cellular based FWA and DSL</td></tr>
<tr><td>New Zealand</td><td>We have Fibre, DSL, HFC, Fixed Wireless Access, and Satellite as the fixed broadband technologies used in New Zealand.</td></tr>
</table>

Question 5: What is the average fixed broadband connection speed per connection (both residential premises and business/ enterprise premises) (e.g., xDSL/ FTTx /FWA/satellite) in your country?

Answer:

<table>
<tr><td>Bhutan</td><td>The normal average leased line internet connections leased by general households is 2 to 4Mbps</td></tr>
<tr><td>Nepal</td><td>Not available</td></tr>
<tr><td>Thailand</td><td>The average fixed broadband connection speed is approximately 100 Mbps.</td></tr>
<tr><td>Japan</td><td>The average speed is not measured.</td></tr>
<tr><td>Malaysia</td><td><table>
<tr><th>Indicator</th><th>Download Speed
(As of January 2023)</th><th>Source</th></tr>
<tr><td>Mean fixed-broadband speed</td><td>138.84 Mbps</td><td rowspan="2">Ookla speedtest global index</td></tr>
<tr><td>Median fixed-broadband speed</td><td>92.69 Mbps</td></tr>
</table></td></tr>
<tr><td>Australia</td><td>In Australia, 95% of broadband connections are delivered by the government-owned National Broadband Network (NBN Co.). There is also a significant enterprise market, but data on enterprise speeds and performance are not collected. Data is also not separately available for business premises.
The following applies only to residential customers. nbn products are sold by speed, so consumers get whatever speed they select ranging from 12Mbps to 1Gbps. The following shows the average available speed and then the most popular product (ie: what speed plan the majority of customers are paying for).
Statistics collected by the competition regulator show:
> The average speeds available for FTTP are 276 Mbps.
> 46% of FTTP connections are on 50 Mbps
> Average speed available for FTTC, FTTB, FTTN and HFC is 46.75 Mbps
> 62% of these connections are on 50 Mbps
> Average speed available on fixed wireless is 37.3 Mbps
> 60% of connections are on 60 Mbps.

Source: December quarter 2022 report | ACCC</td></tr>
<tr><td>Indonesia</td><td>The average fixed broadband connection (FTTx) for downlink is 25.45 Mbps and the average uplink speed is 12.95 Mbps (Ookla, December 2022).</td></tr>
<tr><td>India</td><td></td></tr>
<tr><td>Vietnam</td><td>In recent survey, it showed that average fixed broadband connection speed per connection in Viet Nam, depending on operators, are in the range from 50 Mbps to 100 Mbps.</td></tr>
<tr><td>China</td><td>554 million fixed broadband users reached the access rate of 100 Mbit/s, accounting for 93.9% of broadband users. 91.75 million fixed broadband users reached the access rate of 1000 Mbit/s, accounting for 15.6%. The total bandwidth of fixed broadband users reaches 1993.3 million Gbit/s. The average subscribed bandwidth per household has reached 367.6 Mbit/s.
https://www.miit.gov.cn/jgsj/yxj/xxfb/art/2023/art_69798e71872c407ab677fd1c73885337.html</td></tr>
<tr><td>Korea</td><td>10 Gbps is the average speed for fixed broadband connection using FTTx.</td></tr>
<tr><td>Sri Lanka</td><td>Average xDSL Throughput – DL 30 UL 2 Mbps
Average FWA Throughput – DL 22 UL 4 Mbps
Average FTTX Throughput –DL 95 UL 47 Mbps</td></tr>
<tr><td>Brunei</td><td>As of June, average speed 50 mbps (one operator only)</td></tr>
</table>

Pakistan	8 – 10 Mbps
Palau	5 Mbps – 20 Mbps residence For business - Palau's Fastest DSL provider, PNCC offers high-speed broadband DSL and Fiber Optic solutions for your fast paced business. PNCC understands the technology budget challenges, so we have developed "Commercial DSL Contracts" that should meet your needs. Please inquire about Commercial DSL Contracts
New Zealand	Information on downlink and uplink connection speeds are available on: https://public.tableau.com/app/profile/commerce.commission/viz/MeasuringBroadbandNewZealandDashboard/Overview

Question 6: Which WAS/RLAN technologies are used in your country, for example Wi-Fi, LTE-U, NR-U? And what are the use cases for these technologies?

Answer:

Bhutan	Wi-Fi
Nepal	Wi-Fi is the only WAS/RLAN technology currently in use in Nepal. NTA has successfully completed the wireless broadband project in karnali province using universal service obligation fund, also called RTDF in Nepal. Besides this NTA has developed and completed several wireless project covering various religious destinations, Everest Basecamp trekking route , Round Annapurna circuit among others.
Thailand	WiFi technology is used in 2.4 GHz and 5 GHz frequency bands. LTE-U technology is used in 5 GHz frequency band.
Japan	The technical standards have been established for WAS/RLAN technologies, and the use of any technology and its utilization for any use case are permitted as long as the above standards are followed.
Malaysia	As to date, Wi-Fi is the widely used technology for WAS/RLAN. Some of the use cases of WAS/RLAN include Internet Access, Mobile Device, Home Networking, Smart Home Device, Business Networking, Internet of Things (IOT) and Education.
Australia	As the vast majority of WAS/RLAN use in Australia is authorised under class licensing, and Australian regulations are also generally technology-neutral, so users are free to deploy any technology that meets applicable technical conditions. We therefore have no specific record of which technologies are deployed, or their use cases.
Indonesia	WAS/RLAN a. WiFi/RLAN : used for access and backhaul. b. 5 GHz band (5150 – 5350 MHz and 5725 – 5825 MHz) opened for class-licensed IMT-based technology such as LAA
India	License exemption is technologies neutral. WAS/RLAN technologies use cases in India are predominantly for Home Broadband, Enterprise Broadband and Public Wifi hotspots
Vietnam	Up to now, WAS/RLAN technologies are used in Vietnam that has been just Wi-Fi. The use cases for this technology are public/private Wi-Fi access, wifi direct, bluetooth, Ip camera, remote control.
Korea	WiFi 6E is used for WAS/RLAN technologies and use cases are attached as Annex 3-1.
Sri Lanka	Wi-Fi, Zigbee Wi-Fi- Private LAN, Zigbee- smart meters
Brunei	WAS/RLAN commonly used as home broadband and low powered device in our country.
Pakistan	Wi-Fi to the extent of indoor.
Palau	U-NII and IEEE 802.11
New Zealand	The permitted technologies need to be in accordance with the General User Radio Licence for Short Range Devices

	https://www.rsm.govt.nz/about/publications/gazette-notices/general-user-radio-licence-gurl-notices/ and compliance requirements for suppliers. This is found in https://www.rsm.govt.nz/business-individuals/supplier-compliance/steps/step1-meet-standards/, including the Radio Regulations (Radio Standards) Notice.

Question 7: What is your country's spectrum plan on the 6 GHz band for WAS/RLAN use?

Answer:

Bhutan	We have not yet planned the 6GHz band for WAS/RLAN since it is explicitly used by the satellite services at the moment. In future, with the coming of WiFi-6, we may look into refarming for WAS/RLAN.
Nepal	As the 6 GHz band is currently used for FS/FSS services, there is no immediate action plans related to the use of 6 GHz band for WAS/RLAN. At the moment, Nepal is monitoring the international developments in this topic.
Thailand	The equipment using the band 5.925-6.425 GHz is license exempted and can be used freely nationwide. (RLAN). The use of the band 6.425-7.125 GHz is planned to be considered after WRC-23.
Japan	The national regulation was revised to allow WLAN operations in the 5925-6425 MHz frequency band in September 2022. The 6425-7125 MHz frequency band is under consideration for future assignments.
Malaysia	Malaysia has made available the 5925 MHz to 6425 MHz frequency band for WAS/RLAN under the Class Assignment for Short-range Radiocommunication Device. Malaysia is currently monitoring the international development and studies of the 6 GHz band in view of any future considerations of the 6425 MHz to 7125 MHz frequency band.
Australia	The ACMA has authorised 2 classes of device in the 5925–6425 MHz ('lower 6 GHz') band. These two classes of device are often referred to as low power indoor (LPI) and very low power (VLP). The proposed power limits and restrictions specific to these classes are: • For LPI devices: maximum power 24 dBm EIRP maximum power density 11 dBm/MHz EIRP must operate indoors. • For VLP devices: maximum power 14 dBm EIRP maximum power density 1 dBm/MHz EIRP may operate in any location.
Indonesia	No definitive plan.
India	This is still under study and evaluation phase.
Vietnam	Currently, there is no spectrum plan or regulation for the use of WAS/RLAN in the 6 GHz band. We are considering to allocate spectrum for RLAN and/ors IMT in 6 GHz band, taking into account international trend and country need for the development of nation broadband infrastructure.
China	China will identify the band 6425-7125 MHz or portions thereof, for IMT in the new version of the Regulations on the Radio Frequency Allocation of China. Currently there's no plan to use 6GHz band for WAS/RLAN in China.
Korea	Since 2022, the frequency band 5 925-7 125 MHz has been opened for WAS including WiFi 6E with license-exempt usage, and WiFi 6E will be evolved to WiFi 7 after 2024.
Sri Lanka	5.925GHz to 6.425 GHz
Brunei	5925 to 6425 MHz (500 MHz)
Pakistan	In Pakistan co-existence studies are going on for adoption of 6 GHz band for Wi-Fi-6E with respect to satellite uplink operations.
Palau	no current plan
New Zealand	The 5925 - 6425 MHz frequency range has been made available in New Zealand to WAS/RLAN and information was provided in the General User Radio Licence for Short Range Devices https://www.rsm.govt.nz/about/publications/gazette-notices/general-user-radio-licence-gurl-notices/.

	The 6425 -7125 MHz frequency range is still to be considered, taking into account international and regional developments, including Wi-Fi, Mobile (IMT) and any possible shared use of spectrum. Further information on this is outlined in the New Zealand Spectrum Outlook https://www.rsm.govt.nz/about/publications/spectrum-outlook-and-annual-reports/new-zealand-spectrum-outlook-2023-management/

Question 8: What are the incumbent services and their frequency ranges in the 6 GHz band?

Answer:

	Frequency Range	**Incumbent services**	**Conditions**
Bhutan	6GHz	Satellite Services (VSAT) and Television Satellite	
Nepal	5925 MHz - 6425 MHz	Fixed Point to Point Microwave Link	NA
	6425 MHz - 6700 MHz	Fixed Satellite Services	NA
	6425 MHz - 7125 MHz	Fixed Point to Point Microwave Link	subject to the co-ordination with FSS Allocation
Thailand	5.925-6.425 GHz	Fixed-satellite service (Uplink)	
	6.425-7.125 GHz	Fixed-satellite service (Uplink) and Fixed service	
Japan	5 925-6 425 MHz	FIXED FIXED SATELLITE (Earth-to-space)	
		MOBILE	Low-Power Data Transmission System shall be used
	6 425-6 570 MHz	FIXED FIXED SATELLITE (Earth-to-space) MOBILE	
	6 570-6 870 MHz	FIXED FIXED SATELLITE (Earth-to-space)	
	6 870-7 075 MHz	FIXED FIXED SATELLITE (Earth-to-space) MOBILE	
	7 075-7 125 MHz	FIXED MOBILE	
Malaysia	5925 MHz to 7075 MHz	Fixed Satellite Service Earth Station (VSAT/Hub station)	● Use by way of Apparatus Assignment (licensed apparatus) and Class Assignment* (Non-licensed apparatus). For FSS use under the Class Assignment, the requirements and conditions are specified in Class Assignment for Fixed-Satellite Service Earth Station.
	5925 MHz to 7125 MHz	Fixed Service ● Microwave Link ● Outside Broadcast Microwave Link	● Use by way of Apparatus Assignment (licensed apparatus). ● Fixed service operates on non-interference basis (NIB) to the earth stations of Fixed Satellite Service. Other requirements/conditions are specified in the relevant documents which can be found at this URL:

			https://www.mcmc.gov.my/en/spectrum/standard-radio-system-plan-resources: ●
	5925 MHz to 6425 MHz	Short-range Radiocommunication Device (including WAS/RLAN)	● Use by way of Class Assignment (Non-licensed apparatus) 1. The relevant requirements and conditions are specified in the Class Assignment for Short-range Radiocommunication Device (SRD) (please refer to the answers provided in Question 1 above).
Australia	5925 – 6425 MHz	Fixed Earth – 284 Point to Point links – 2179 Radiodetermination – 1	
	6425–7125 MHz	Fixed Earth – 23 Earth Receive – 9 Point to Point links – 2661 Radiodetermination – 7	
Indonesia	6 425 – 7 110 MHz	Fixed Wireless Point to Point (Microwave Link)	utilized service
	5 925 – 6 725 MHz	Fixed Satellite Service	utilized service
	6 725 – 7 025 MHz	Fixed Satellite Service	planned band
India	5925-6425 MHz	Fixed Service (Point to Point links), FSS (E-to-s)	
	6 425-6725 MHz	FSS (E-to-s)	
	6725-7025 MHz	FSS (E-to-s), Fixed Service (Point to Point links)	
	7025-7125 MHz	Fixed Service (Point to Point links)	
Vietnam	5925-6425 MHz	FIXED FIXED-SATELLITE (Earth-to-space) MOBILE	RR. No. 5.457A 5.457B 5.149 5.440 5.458
	6425-6700 MHz	FIXED FIXED-SATELLITE (Earth-to-space) MOBILE	RR. No. 5.457A 5.457B 5.149 5.440 5.458
	6700-7075 MHz	FIXED FIXED-SATELLITE (Earth-to-space) (space-to-Earth) MOBILE	RR. No. 5.441 5.458 5.458A 5.458B **VTN16** **VTN16** The following frequency bands are preferred for the use of systems in the Fixed-satellite service: 3400-3560 MHz (space-to-Earth direction) 6425-6725 MHz (Earth to Space) 10700-11700 MHz (space-to-Earth direction) 12750-13250 MHz (Earth to Space) 13750-14000 MHz (Earth to Space) 14250-14500 MHz (Earth to Space) Earth stations operating in the bands 3400-3560 MHz and 10700-11700 MHz must employ the receiver filters to reject out-of-band signals in accordance with the regulations specified by the Ministry of Information and Communications. Systems in other services operating in this band shall not cause harmful interference to and shall not be protected from harmful interference cause by systems in the Fixed-satellite service.

	7075-7110 MHz	FIXED MOBILE	RR. No. 5.458
China	5925-6700 MHz	FIXED FIXED-SATELLITE (Earth-to-space) 5.457A MOBILE CHN38 5.149 5.440 5.458 CHN12 CHN18 CHN23	
	6700-7075 MHz	FIXED FIXED-SATELLITE (Earth-to-space) (space-to-earth) 5.441 MOBILE 5.458 5.458A 5.458B CHN23	
	7075-7145 MHz	FIXED MOBILE 5.458 CHN23	
Korea	6 425 ~ 6 605 MHz 6 765 ~ 6 945 MHz	Broadcasting (Fixed)	
	6 605 ~ 6 765 MHz 6 945 ~ 7 125 MHz	Broadcasting (Mobile)	
	5 925 ~ 6 425 MHz 6 430 ~ 7 110 MHz	M/W (Fixed)	
	6 876 ~ 7 051.86 MHz	Satellite (Feeder link)	
Sri Lanka	5.925 – 6.700 GHz	FIXED FIXED-SATELLITE (Earth-to space) MOBILE *Satellite - Fixed Earth Station Fixed Service – Network* *Maritime - Maritime Mobile*	
	6.700 – 7.075 GHz	FIXED FIXED-SATELLITE (Earth-to space) (space-to-Earth) MOBILE *Fixed Service - Network*	
	7.075 – 7.145 GHz	FIXED MOBILE Fixed Service - Network	
Brunei	5925-6425 MHz	Fixed	
	6425-7125 MHz	- Fixed-Satellite Service (Uplink) - Fixed Service	
Pakistan	5925 – 7425 MHz	- Fixed	
	5925 – 6425 MHz	- FSS (uplink)	
Palau	6415.84 – 6417.64 MHz	-	In progress

	6280.397 – 6281.547 MHz	-	In progress
New Zealand	Please refer to the New Zealand Table of Radio Spectrum Usage in New Zealand in PIB 21 https://www.rsm.govt.nz/about/publications/pibs/pib-21/.		

Question 9: Does your administration have a frequency assignment/license database system for the 6 GHz band? If there is such a database, is it open to public for 3rd coordination system to interact with? Please provide some details

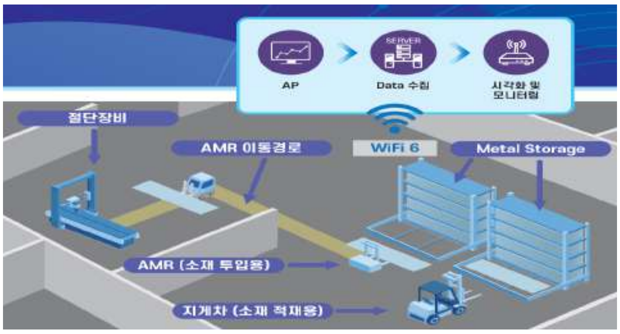
Answer:

Bhutan	N/A
Nepal	The assignment database is maintained for Fixed Satellite Service and Fixed Services (Microwave) separately. But such database is not publicly available.
Thailand	There is a frequency assignment/license database system, but it is not open to public.
Japan	Yes, we have a database system for all domestic radio stations, which is available on the MIC website.
Malaysia	The frequency bands assigned under the Apparatus Assignment are registered in MCMC's Spectrum Management System. Some information of frequency assignments (such as transmit/receive frequencies, assignment holders, location, etc.) are available in MCMC's website, which can be found at https://www.mcmc.gov.my/en/legal/registers/cma-registers. There is no frequency database system for short-range radiocommunication devices (including WAS/RLAN) under the Class Assignment.
Australia	Yes, publicly available and searchable database, the Register of Radiocommunications Licenses at https://web.acma.gov.au/rrl/register_search.main_page ,however note that devices authorized by Class Licence do not appear on the register. The information on licensed services given in answer to question 8 is taken from this data.
Indonesia	Yes, there is license database for 6 GHz band existing usage. It is not open to public for 3rd coordination system to interact with.
India	There is a robust licensing and frequency assignment system in place. Yes, India does have frequency assignment/license database system for the frequency bands including 6 GHz band. Wireless Planning and Coordination Wing (WPC) is nodal agency to do any coordination.
Vietnam	Yes, the administration has. However, in current regulations, it is not open to public for 3rd coordination system to interact with.
China	Yes, there's database system. However, there's no plan to public the database for any 3rd system as it might bring risk.
Korea	The Republic of Korea has a frequency assignment/license database system for all radio stations including 6 GHz band and a plan to develop for 6 GHz frequency coordination system in near future.
Sri Lanka	No
Brunei	There is a frequency assignment/license database system, but it is not open to public.
Pakistan	In Pakistan we maintain a database of all authorized/ licensed users including operations in 6 GHz band. Currently, it is not open to public for 3rd party coordination system to interact with.
Palau	In Progress
New Zealand	New Zealand's Frequency assignment/licence database is the Register of Radio Frequencies (RRF) which contain the records held by Radio Spectrum Management (RSM). The RRF can be accessed by visiting https://rrf.rsm.govt.nz/ui?state=1

Annex 3-1: Korea’s detailed response to Question 6

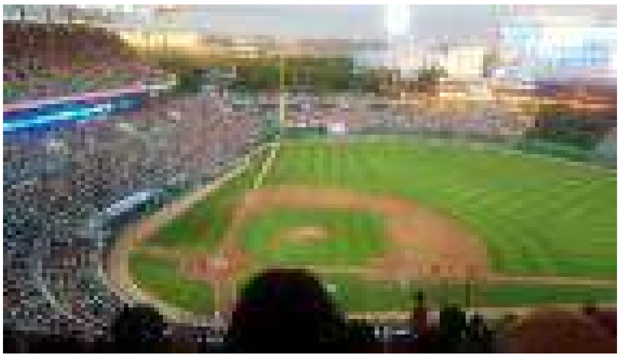
Question 6: Which WAS/RLAN technologies are used in your country, for example Wi-Fi, LTE-U, NR-U? And what are the use cases for these technologies?

Technology	Frequency	Use case	Remarks
Wi-Fi 6(E)	5/6 GHz	**<Business Solution>** 1) Wi-Fi 6E and AI robot-based smart solution for businesses*: Building a high-capacity, low-latency, and multi-connection environment with Wi-Fi 6E in small business, and executing automatic order taking, easy payment, serving, and checkout scenarios with AI serving robots.  2)Customer service through CR code in business stores, based on Wi-Fi 6E*: Implementation of a Wi-Fi 6E service in small business stores that provides contactless services such as displaying menus, ordering, and payment to users who connect through a QR code. A big data collection platform is also implemented for marketing information targeting small businesses. 	*The technology and service demonstration items are developed by small and medium-sized venture entrepreneurs with the support of the Korean government and the Korea Radio Promotion Association

		 3) Logistics warehouse service using Wi-Fi 6E-based AMR (Auto Mobile Robot)*: Demonstration of a smart logistics integrated management system by integrating a Wi-Fi 6E-based mesh configuration and an AMR (Auto Mobile Robot) based logistics management platform at an air logistics center.  **<Education and Learning>** 1) Providing education and training services to the classroom using next-generation Wi-Fi 6E-based immersive contents*: Real-time two-way online education program is created using VR contents based on Wi-Fi 6E, and a high-quality educational environment is established.	

		  2) Realistic tour guide service using Wi-Fi 6E in exhibition and experience spaces *: By using Wi-Fi 6E, real-time transmission of large 3D/VR immersive contents is served to two exhibition halls of the National Science Museum. Meta-verse experience services based on kiosks and Holo-lens 2 are provided.  **<Navigation>** 1) Wi-Fi 6E-based high-precision AR Navigation*:	

		 Providing location-based AR navigation services to users who are connected to Wi-Fi 6E at a distance by combining visual positioning system (VPS) data with AR content.  **<Streaming Service>** 1) Seamless data roaming service with 6GHz Wi-Fi technologies*: At the outdoor gates of Airport, it is possible to connect to a 6 GHz Wi-Fi network using a smartphone while moving around. By utilizing roaming and mesh networking capabilities, it is possible to maintain Wi-Fi service and enable video calls and streaming of 4K-quality video content..	

		.  2) Non-face-to-face sports relay service using AI and Wi-Fi*: Utilization of AI and Wi-Fi 6 GHz for contactless sports broadcasting services. Simultaneous live broadcasting of sports games through AI cameras, transmitting two types of video in FHD and panorama to provide the game footage to both the stadium audience and viewers.  3) 8K level interactive service using 6GHz band*: Real-time streaming service of VR contents featuring world natural heritage sites for visitors of a VR theme park in a botanical garden, accessed through an Android-compatible 8K VR player app.	

		 4) Watching local broadcast channels provided through terrestrial ATSC 3.0 on-vehicle using Wi-Fi 6E. *: Demonstration of free UHD broadcast service through mobile devices by receiving multi-channel UHD terrestrial broadcasting on a moving bus, converting and transmitting it through Wi-Fi 6E.  **<Performance test>** 1) Performance comparison experience and visualization between existing Wi-Fi and Wi-Fi 6E*. Verification and visualization of performance comparison, such as actual measured speed, between LTE, 5G, Wi-Fi 5/6/6E.	

		 2) Wi-Fi 6E outdoor MESH network*. Validation of stable internet service by constructing a  mesh network using 9 or more Wi-Fi 6E access points as multi-nodes in public places, and verifying and comparing network performance based on signal strength.	
LTE-U	5GHz	1) Public Wi-Fi offloading for data traffic from public Wi-Fi networks to LTE-U networks 2) Mobile video for providing high-quality mobile streaming video and live video 3) Internet of Things (IoT) for providing wireless connectivity to IoT devices 4) Emergency services for providing wireless connectivity to emergency services for police, fire, and medical services	
NR-U	5/6GHz	Not yet	